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VOLVULUS OF THE STOMACH*

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Since Berti[1] first described a case of volvulus of the stomach in 1866, there has been an increasing awareness of this entity, much of it through the popularity and use of diagnostic radiology. Buchanan,[3] in 1930, reviewed 42 cases, and Lazarini,[7] in 1940, reported 90 such cases. A survey reveals over 260 reports, in each of which at least 1 case is presented. The condition has deserved only passing mention in the majority of textbooks, even though it is being more frequently encountered. It is still frequently diagnosed at operation in the acute form; and in the chronic form, only after a long period of being unsuspected. This presentation consists of an additional case of chronic volvulus.

CASE REPORT

History. A 41-year-old white woman had a history of 8 years of symptoms related to the chest and abdomen, before being seen by us. At onset, a gastrointestinal series revealed a volvulus of the stomach. After 2 phrenic nerve procedures for an associated pleuritic pain, relief was temporarily afforded. She had complained of cutting, colicky, epigastric pain, 4 years before being seen by us. A large splenic cyst was discovered and removed, with symptomatic relief for 2 years. She then began having recurring, epigastric pain, associated with nausea and vomiting. On roentgen examination, the volvulus was again noted and gastropexy was performed. Cessation of symptoms lasted until 3 months before her admission when she developed paroxysms of right costal pain, radiating to the back, and across the abdomen. These were aggravated by walking or jarring and lasted 30 minutes to 1 hour. Several episodes of nausea, vomiting, and abdominal distention, causing incapacitating pain, required narcotics. Significant weight loss ensued.

Diagnosis. Roentgenograms revealed organoaxial volvulus of about 90°, and a paralyzed left diaphragm. The transverse colon was high, but no obstruction or other significant abnormalities were noted. Exploration of the abdomen was made through a left, upper rectus incision. Dense anterior abdominal adhesions, involving the large and the small intestines, were encountered. The stomach was in 90° degree rotation and appeared to be fixed by adhesions. There were two areas of scarring, one at the pylorus, and another high in the fundus. A 60 per cent subtotal gastrectomy, with anterior Hofmeister gastrojejunostomy, was performed. The pathologic specimen contained an active ulcer near the pylorus. An obstruction at the stoma, probably due to rotation of the gastric pouch, complicated the postoperative course. It was relieved by intubation and supportive measures. Thrombophlebitis occurred at the site of an indwelling polyethylene tube, with subsequent cellulitis, which responded to appropriate therapy. Follow-up has revealed complete amelioration of symptoms.

DISCUSSION

There have been at least 4 cases of volvulus reported as a complication of phrenic interruption.[11] In the case discussed, it is believed that the volvulus antedated the phrenic nerve crush. In view of the operative findings, the correlation between the volvulus and the symptoms is in question.

The following classification of volvulus of the stomach has been usually accepted:[3, 4, 8, 9]

I. Type of rotation

A. Mesenterio-axial—Rotation about an

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axis perpendicular to the lesser curvature

B. Organo-axial—Rotation about an axis going through the fixed points of the esophageal and pyloric attachments

II. Extent

A. Total—All (or practically all) of the organ involved in the rotation

B. Partial—Only a portion of the organ involved

III. Direction

A. Anterior—Rotating part moves anteriorly over organ

B. Posterior—Rotating part moves posteriorly (very rare)

There are both acute and chronic forms of volvulus of the stomach. The acute is usually idiopathic, shows 180° or more rotation, and there is a rapidly progressing clinical course of high obstruction. If the volvulus is total, with all of the organ involved, occlusion at the pylorus and the esophagus occurs. The pylorus is first involved through twisting and kinking; distention rapidly ensues, with narrowing wedge conformation of the lesser curvature, bringing the cardia and the pylorus together, and occluding the esophagus.[3] The marked distention of the stomach produces bluish discoloration and thinning of the wall. Edema of the duodenum and the esophagus is seen. Surprisingly, severe impairment of the gastric blood supply is not the rule, and the reduced stomach usually returns to a normal state, with gangrene occurring rarely, although it has been reported.[6] If uncorrected, the result is rupture of the distended stomach. The malpositioned stomach may cause secondary distention of the right transverse colon as the colon is pulled up by the omentum and interposed between the dilated stomach and the anterior abdominal wall.[3] The neighboring spleen and pancreas may also be displaced. Complications of rupture of the splenic vessels and fat necrosis near the tail of the pancreas have been reported.[3] A partial volvulus may also produce the acute picture, but the dilated mass is then usually bilocular because of the twist which occurs when the stomach has folded upon itself.

Chronic, mild, or intermittent volvulus produces less severe symptoms of obstruction and

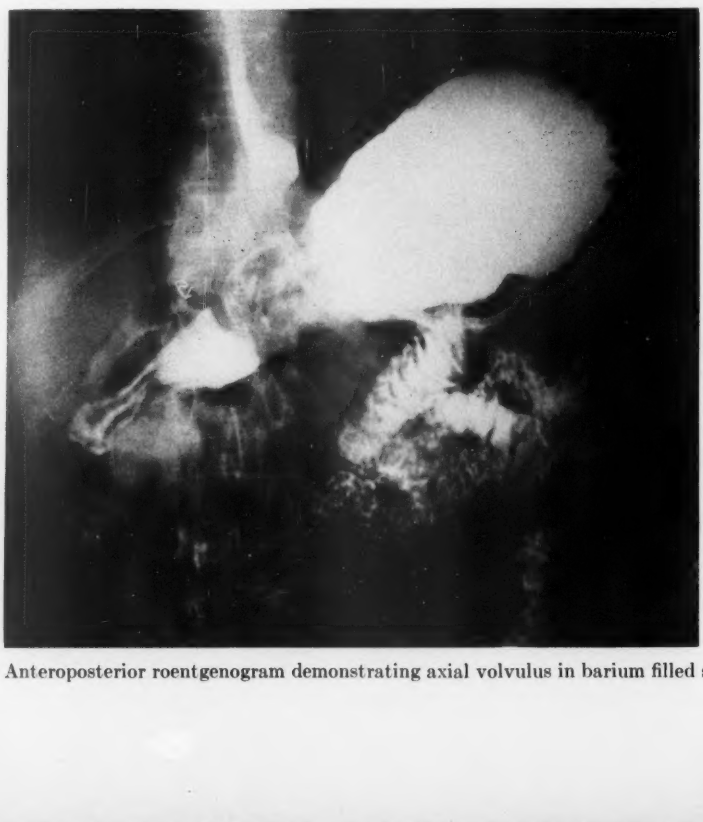

FIG. 1. Anteroposterior roentgenogram demonstrating axial volvulus in barium filled stomach

FIG. 2. Lateral view demonstrating volvulus of the stomach

digestive disturbance over a long period. Numerous other primary diseases are seen in this chronic group.[10] Rotation is usually less than 180° and tends to be stationary, or to recur frequently. Many cases are asymptomatic and are incidentally found.

Sex distribution is approximately equal. Peak incidence is in the fifth and sixth decades of age, although isolated cases have occurred even in infancy.[2, 3] Idiopathic volvulus, usually acute, is associated with excessive mobility of the stomach, especially the pylorus. Frequently, relaxed gastrohepatic, renal, or colic attachments are present, and sometimes, a generalized ptosis, or a faulty peritoneal attachment is noted.[8, 9] Secondary volvuli are associated with (1) hernia, or eventration of the diaphragm; (2) peptic ulcer, and/or hourglass stomach; (3) tumors of the stomach; (4) inflammatory processes; (5) displacement by other organs; (6) phrenic interruption; (7) trauma; or (8) tears in the transverse mesocolon or the hepatic omentum.[3, 4, 8, 11]

A number of immediate exciting causes play a part in some cases. Among these are: overfilling; vigorous peristalsis; antiperistaltic waves; acute dilation of the ptosed stomach; trauma to the abdominal wall; or air in the colon.[3, 5, 9, 10]

In the acute type of volvulus, the symptoms are more pronounced, dramatic and characteristic. The triad of vomiting followed by retching, circumscribed epigastric pain and inability to intubate the stomach has been described as fairly constant.[8] Onset of pain is sudden and severe. There is rapidly developing upper abdominal distention, frequently with a large palpable mass. The pulse is rapid, respirations are increased, and there is slight temperature elevation. Abdominal tenderness is at first epigastric, but soon becomes generalized.[2]

The previously mentioned inability to pass a stomach tube is quite characteristic. The course is rapid, and death usually occurs if the condition is not treated. In the chronic, or intermittent, variety symptoms may be absent. However, the patient may present a long history of vague gastrointestinal symptoms which have been overlooked for many years. Bloating, vomiting, epigastric distress, or frank pain, lasting from a few minutes to several hours,

with spontaneous remissions, are the rule. Diagnosis can be made radiographically.

Among the various findings on roentgen examination are: the greater curvature higher than the lesser, the high position of the stomach, the duodenal bulb pointing downward and to the right, and a double fluid level. The stomach, in addition, has a cascaded appearance, and there is narrowing of the pars media, with a spiral appearance of the rugae perhaps being demonstrated.[4]

The acute form may be diagnosed preoperatively, but frequently is not. The condition must be differentiated from perforated viscus, intestinal obstruction, acute pancreatitis, mesenteric embolus, strangulated ovarian cyst, and many other conditions. The chronic form is often thought to be gastritis, peptic ulcer, or gall bladder disease.

If the initial attempt at intubation and gastric decompression is unsuccessful, the acute volvulus demands immediate exploration. At times, decompression must be initiated by means of a trocar to bring about the reduction. The acute volvulus is most often idiopathic and seldom shows tendency to recur.[2] Cases have been reported in which successful detorsion of the stomach has occurred without operation.

In chronic or intermittent volvulus (and in some acute cases) there are primary disease processes which should be dealt with surgically to effect cure. These include repair of diaphragmatic hernia and appropriate treatment for tumors and ulcers. Gastropexy is a plausible treatment, but as has been previously stated, the idiopathic acute volvulus seldom recurs, once it is reduced. Gastroenterostomy is frequently helpful, especially if the volvulus is secondary to a stenosing ulcer. The treatment of choice for the chronic recurring type, associated with an ulcer, is gastric resection.[2]

SUMMARY

1. Volvulus of the stomach has been recognized since 1866, and although still rarely reported, is being found more frequently.

2. A case of chronic volvulus is reported. This was associated with a previous phrenicectomy and an active benign gastric ulcer.

3. A classification of types of volvulus is presented.

4. The symptom triad of (1) vomiting which may proceed to retching, (2) circumscribed epigastric tenderness and (3) inability of the patient to be successfully intubated is characteristic of acute volvulus. Chronic volvulus may be asymptomatic, or may present a long history of vague epigastric pain and intermittent transient obstruction.

5. Treatment consists of early operation, with reduction and decompression, in the acute volvulus. In chronic volvulus, the measures include correction of primary disease, gastropexy, gastroenterostomy and gastrectomy.

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SPONTANEOUS RUPTURE OF THE LIVER ASSOCIATED WITH PREGNANCY: CASE REPORT AND REVIEW OF THE LITERATURE*

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Spontaneous rupture of the liver associated with pregnancy is an exceedingly rare and interesting clinical entity. Previously in the literature, 20 cases of this condition have been reported. The earliest documented case was reported in 1844 by Abercrombie,[1] whose patient, a 35-year-old woman, died in the third trimester from hemorrhage of the liver. He believed that the liver, softened and congested by gestation, was ruptured by the trauma of tying a handkerchief around the upper abdomen. None of the subsequently reported cases, however, have been associated with significant trauma. This report includes the 21st case of spontaneous rupture of the liver associated with pregnancy and a review of the literature.

Although spontaneous rupture of the liver in pregnancy is rare, its lethal nature deserves emphasis. The present patient represents only the sixth survivor; the other 15 patients died in shock as a result of uncontrollable and usually unsuspected hemorrhage from the liver during various periods of gestation. This 71 per cent maternal mortality rate might be reduced if this disease were suspected and an immediate operation performed for the control of hemorrhage.

CASE REPORT

R. A. was a 28-year-old gravida VIII, para VII, colored woman, whose last menses occurred on May 17, 1958. She was admitted to the Tulane Obstetrical Unit of Charity Hospital on January 12, 1959, with right upper quadrant abdominal pain which radiated to the right shoulder and subcapsular area, and was accentuated by deep breathing. There was a history of fatty food intolerance and bouts of right flank pain for 1 year.

On admission, vital signs included blood pressure of 170/120, pulse rate of 90, respiratory rate of 16, and temperature of 98°. She was obese and in moderate distress from abdominal pain. Examination revealed minimal guarding and tenderness to deep palpation in the right upper quadrant. The uterine fundus measured 27 cm. above the symphysis pubis. Fetal heart tones of 140 beats per minute were present in the left lower quadrant. Pelvic examination revealed a long, closed cervix and a vertex presentation at floating station. All reflexes were normal, and a trace of pedal edema was noted.

Laboratory data on admission were as follows: hematocrit, 31 volume per cent; white blood cells (W.B.C.) 9800 with 81 polymorphonuclear cells; urinalysis, 1^+ albumin, specific gravity, 1.022; 2 to 3 red blood cells per high power field (R.B.C./HPF); occasional fine granular casts, and no W.B.C. Urine bilirubin and urobilinogen were negative; CO_2, 21.6 mEq./L.; blood urea nitrogen (B.U.N.) 8 mg. per cent; chloride, 105 mEq./L.; serum protein, 6.1 gm. per cent; serum amylase, 136 units; cholesterol, 274 mg. per cent. Chest and abdominal x-rays revealed a normal chest and a 7-month-old fetus. No stones were seen in the right upper quadrant.

With a tentative diagnosis of mild acute cholecystitis, nasogastric suction was instituted and an antispasmodic drug administered parenterally. Fourteen hours after admission the patient went into spontaneous labor. After three hours she delivered an 1840-gm. living, male infant. The estimated blood loss at delivery was 150 cc. After delivery the patient appeared to improve and the upper abdominal pain and tenderness became less evident.

Several hours after delivery, however, the patient began to complain of more severe and generalized abdominal and right shoulder pain accentuated on inspiration. Generalized direct and rebound abdominal tenderness and absence of bowel sounds were noted. Pelvic examination revealed a well contracted uterus with no evidence of laceration or hematoma. Repeat hematocrit determination was 25 per cent. Culdocentesis produced 50 cc. of dark, nonclotting blood.

With a preoperative diagnosis of intra-abdominal bleeding, the patient's abdomen was explored. Approximately 1000 cc. of blood were found in the peritoneal cavity. Pelvic exploration revealed normal postpartal uterus and adnexae, and no source of bleeding was apparent. The bleeding

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arose, it was discovered, from the upper abdomen which necessitated extension of the paramedian incision to the right costal margin. The spleen was normal. Exploration of the liver, which was enlarged, soft, and yellowish brown, revealed an extensive subcapsular hematoma over almost the entire dome of the right lobe. No actual laceration or point of rupture of the hematoma could be detected, but slow bleeding continued from the periphery of the hematoma. The remaining portions of the liver, including the inferior surface of the right lobe, showed no abnormality. The bleeding appeared to originate from a rupture of the hematoma through the capsule of the liver in the posterior portion. The entire surface of the hematoma was tamponaded with two uterine packs and the hepatic artery in the portal triad was occluded manually for 10 minutes. These maneuvers afforded satisfactory hemostasis. The packs were brought out through a separate flank incision. Two units of whole blood were administered during the procedure.

During the first few postoperative days, the patient exhibited a continued hypertension ranging from 160/110 to 190/130 mm., a tachycardia of 120 to 140 per minute, and marked pain on respiration in the lower right chest and right shoulder. Nasal oxygen and frequent endotracheal suction were used because of the limited, painful respiratory excursions and inadequate cough mechanism. A chest x-ray revealed elevation of the right diaphragmatic leaf with patchy atelectasis and pleural reaction in the right lower lung field. The hematocrit remained stable at 30 per cent for several days. Urinary output ranged from 800 to 1500 cc. daily. Daily urinalysis revealed a specific gravity of 1.015 to 1.022, 1 to 3+ albuminuria, 20 to 40 W.B.C. and an occasional fine granular cast/HPF. An elevated B.U.N. of 46 mg. per cent, observed on the second postoperative day, returned to a normal level by the fifth day. Repeated liver profiles showed normal values.

The patient had a febrile course for 12 days, with temperatures ranging from 99° to 101°, despite penicillin, streptomycin, and erythromycin. Only an estimated 200 cc. of serosanguineous fluid per day drained from the packing without any change in the vital signs or hematocrit. On the third day after operation, one-half of the packing was removed, using Trilene anesthesia. There was no renewed bleeding, but a considerable amount of old blood and necrotic tissue was observed. The following day the remaining pack was removed and a large rubber drain was inserted. Upon removal of the packs, the dyspnea and right lower chest pain subsided. The temperature returned to normal and all antibiotics were discontinued after removal of the drain. X-rays at this time showed a small pocket of fluid anteriorly beneath the elevated right leaf of the diaphragm.

On the 17th day after operation the temperature rose to 102° and the patient complained of a dull soreness in the right lower chest region anteriorly and posteriorly. Repeat x-rays demonstrated an immobile, markedly elevated right diaphragmatic leaf, beneath which was a much larger air-fluid level compatible with a subdiaphragmatic abscess.

On February 1, 1959, under intercostal block anesthesia, subperiosteal resection of 3 in. of the ninth rib was performed affording a direct approach to the abscess cavity through an obliterated pleural space. Upon incising the diaphragm, a large infected hematoma in the right anterior superior subdiaphragmatic space, over the dome of the right lobe of the liver, was drained of approximately 500 cc. Culture of the fluid was obtained and biopsy of the necrotic liver lining the base of the cavity was performed. The culture was subsequently reported as *Staphylococcus albus saprophyticus*, which was sensitive to penicillin, erythromycin, and Chloromycetin. Final pathologic diagnosis of the biopsy was necrotic debris, blood clot, and granulation tissue. Three large Penrose drains were placed in the abscess cavity and brought out through the incision. After this procedure the patient became asymptomatic and her temperature returned to normal. The drains were slowly advanced starting on the seventh day after operation and all antibiotics were discontinued on the tenth day.

After repeated visits to the gynecology clinic, the patient was readmitted on August 2, 1959, with a diagnosis of symptomatic uterine prolapse and cystourethrocele. The blood pressure was 170/105 mm. A chest x-ray revealed a slight elevation of the right hemidiaphragm. Laboratory data and liver profiles were within normal limits. A vaginal hysterectomy, anterior colporrhaphy, and posterior perineorrhaphy were performed. After the adequate drainage of a small vaginal cuff abscess, the patient was discharged eight days after the operation.

REVIEW OF THE LITERATURE

Including this report, the literature contains 21 cases of proved spontaneous rupture of the liver associated with pregnancy. The salient clinical features of these cases are summarized in table 1.

Age, Duration of Pregnancy and Gravida

The age range in this group of patients was from 24 to 42 years. There were 6 patients in

TABLE 1

Summary of findings in 21 cases (1–12, 14–20)

	Number	Per Cent
History		
Age range 24–42		
Gestation		
Second trimester	4	20
Third trimester	12	57
Post-partum	3	14
No record	2	9
Symptoms		
Abdominal pain	15	71
Back and/or shoulder pain	6	29
Pain on respiration	5	24
No record	4	20
Dyspnea	3	14
Signs		
Shock	17	81
Toxemia	17	81
Upper abdominal tenderness	8	38
Convulsions	8	38
Results of treatment		
Nonoperative		
Cases	15	
Survivors	0	0
Operative		
Cases	6	
Survivors	6	100

the age group of 26 to 30 years, and 8 were in the age group of 31 to 35 years. These figures fall well within the age range compatible with the normal female reproductive years and are not remarkable.

Spontaneous rupture of the liver occurred in the second and third trimesters of pregnancy and in the immediate postpartal period. In the second trimester there were 4 cases and in the third there were 12. In the 3 cases occurring in the immediate postpartum period, 2 patients were at term and 1 patient was at 7 months.

Every patient reported in this group was multiparous except the primiparous patient cited by Kolossoff.[9] The number of pregnancies recorded in the multiparous women varied from 2 to 8. There was no record of the number of pregnancies in 3 patients. The small number of case reports suggests that this condition occurs more frequently in multiparous women.

Symptoms and Signs

The predominant symptoms were related to the pathologic processes of hematoma formation in the liver followed by rupture of the hematoma and subsequent hemoperitoneum. In 15 cases there were symptoms of pain in the hypogastrium or epigastrium, which in 6 instances radiated through to the back or to the right shoulder. The pain was usually of a dull and intermittent nature, not unlike the pain of biliary colic; and this factor may account for the many erroneous diagnoses of acute cholecystitis. In several cases the pain was sudden and constant in character. Frequent associated symptoms included increased pain with respiration, dyspnea, vomiting and symptoms referable to toxemia of pregnancy. In 4 case reports no symptoms were recorded.

There were only 8 recorded observations of upper abdominal tenderness, which may not reflect the true incidence of this physical finding. In 17 cases there were signs of shock, usually severe in nature, and of toxemia of pregnancy. Of these 17 cases, convulsions occurred in 8 instances.

Results

In this series of 21 cases there were 6 survivals and 15 deaths, representing a 71 per cent mortality rate. Only the 6 patients who were operated upon for suspected massive intra-abdominal hemorrhage survived. Kolossoff's[9] case ended fatally on the operating table during caesarian section. In the remainder of the cases bleeding continued unsuspected and death occurred without abdominal exploration.

Pathology

In most of the reported cases the liver appeared larger than normal, and in several instances, including the present case, was soft and had a yellowish appearance. The common pathologic finding was a large subcapsular hematoma of the liver with rupture of the capsule. In the majority of cases the hematoma was extensive but was limited to the dome of the right lobe. The left lobe was the site of the hematoma in 2 instances, and in 2 cases both lobes were involved with hematoma formation. The successfully treated case reported by Links[12] presented at operation with a 5-cm. knifelike laceration in the caudate lobe, quite unlike the usual cases with large hematomas and associated irregular tears of the liver capsule. Only Lascano[11] noted at autopsy other foci of hemorrhage in the intra-abdominal organs in one of his cases.

The rupture of Glisson's capsule created a hemoperitoneum in the majority of cases, varying in amount from 500 to 2000 cc. In 3 fatal cases no autopsy findings were recorded.

The microscopic study of the liver, available in only 11 of the cases, showed a uniform pattern. There was dissociation of liver cells, some element of fatty degeneration, and foci of lobular necrosis, with surrounding zones of hemorrhage. In only 1 case with operation and survival was a liver biopsy obtained.

DISCUSSION

From the preceding review of 21 cases of spontaneous rupture of the liver associated with pregnancy, it is evident that the condition is rare and usually unsuspected. These factors undoubtedly account for the high mortality rate associated with the disease. The true incidence would probably be greater if this condition were suspected more often and all cases occurring were reported.

The disease has been reported at various ages throughout the normal female reproductive period. It has occurred most frequently in multiparous patients, but has also occurred in one primiparous patient. Usually the condition appears in the third trimester of pregnancy, although it has occurred in the second trimester and in the immediate postpartal period. For this reason, the disease should be suspected without regard to duration of gestation.

The symptoms and signs have been strikingly similar in most cases. Upper abdominal distress is a frequent accompanying symptom of toxemia of pregnancy and should lead to the suspicion that spontaneous rupture of the liver might occur. Most patients noted upper abdominal pain of a dull, intermittent nature which frequently radiated to the back and the right shoulder. Occasionally the initial symptom was sudden, constant pain in the same region. Dyspnea and increased pain on respiration were evident.

Shortly thereafter, the symptoms became progressively more severe, and the pain increased in intensity and spread beyond the initial localized area. Subsequently, and probably related to rupture of the liver capsule with hemoperitoneum, the patients developed shock, which progressively became more severe without blood replacement and immediate operation.

The predominant physical signs in this group of patients were the presence of shock, upper abdominal tenderness, and the presence of toxemia of pregnancy, frequently accompanied by eclamptic convulsions. Eighty-one per cent of the patients presented evidence of shock associated with toxemia before operation or death. With the progression of hemorrhagic shock, anemia due to blood loss developed. In the present case report the hematocrit fell from 31 volume per cent to 25 volume per cent. Shock would probably have developed, had not immediate operation been performed.

It is important to note that only the patients who were operated upon survived. *This rare condition represents a true surgical emergency*, the treatment of which should not include any form of expectant observation or the replacement of suspected blood loss by blood transfusion alone. There is no sign of external blood loss, and pelvic examination may exclude the common causes of prepartal or postpartal hemorrhage. In the present case culdocentesis was of considerable aid in establishing the diagnosis of hemoperitoneum. However, only by abdominal exploration could the etiology of the bleeding be established and the proper treatment be instituted.

The etiology of this disease remains obscure. In Abercrombie's[1] initial case report in 1844, trauma from a tight handkerchief around the upper abdomen was suggested as the probable cause of rupture of the liver. However, there has been no history of significant trauma in any of the remaining cases.

Most authors agree that the one single predisposing factor is toxemia of pregnancy, which was recorded in 81 per cent of this series of patients. So little data was available to the clinician in the remaining cases that this complication of pregnancy might well have occurred in all 21 cases. Speert[18] called attention to the fact that patients with eclampsia were prone to develop spontaneous hemorrhages, notably in the liver, brain, subarachnoid space, kidney, placenta and adrenal glands. Lascano[11] described the hemorrhagic disorder in eclampsia causing spontaneous rupture of the liver as comparable to that involving the genital system and causing premature separation of the placenta. In Welch's[20] case report there was hemorrhage into the brain in addition to the liver. Likewise, in the case

review by Sanes and Kaminski,[17] hemorrhage into the rectus muscle was noted at autopsy. In 1948, Ogden[13] reported a fatal case of an eclamptic patient in the third trimester whose clinical picture was similar to those experiencing spontaneous rupture of the liver. At autopsy his patient was found to have an extensive retroperitoneal hematoma arising near the pancreas.

The exact mechanism of this hemorrhagic tendency in the liver of the eclamptic patient, however, is poorly understood. Dieckman[15] noted abnormal, gross and microscopic changes in the liver of the eclamptic patient as a frequent occurrence. He described the liver surface as scattered with red, irregular patches due to hemorrhagic necrosis beneath the capsule. In his opinion, the primary lesion was a marked dilation of the periportal capillaries with subsequent rupture and thrombosis. The hepatic cells had become compressed between the distended sinusoids, resulting in focal areas of necrosis. It should be noted, however, that liver biopsies in pregnant women, with and without toxemia, have shown no significant difference. Lascano[11] theorized that the toxemia of pregnancy caused an increased vascular fragility and an alteration in blood coagulability. Howard and Fandrich[7] pictured the sequence of events as follows: infarction, hypervascularization at the periphery of the infarct, rupture of a vessel, intrahepatic hemorrhage, rupture of tissue, subcapsular hematoma, perforation of the capsule and hemoperitoneum.

Several authors, notably Roemer,[16] Speert,[18] and Sanes and Kaminski,[17] believe that the effects of increased intra-abdominal pressure from convulsions, gestation and vomiting may contribute to the rupture of the liver already congested by pregnancy and toxemia.

MANAGEMENT

The successful management of spontaneous rupture of the liver begins by suspecting it in every patient with toxemia. A search should also be made for other manifestations of this hemorrhagic disorder—abruptio placenta, cortical necrosis of the kidney, and hemorrhage into the adrenal glands and brain. A cul-de-sac puncture will verify the presence of a hemoperitoneum, and this finding, correlated with the clinical picture, will help substantiate the diagnosis of rupture of the liver. Adequate blood replacement should be given before operation to combat the state of shock, which becomes progressively more severe if untreated.

At operation a systematic exploration of the abdomen is necessary to locate the source of bleeding. Particular attention should be given to the genital organs, liver and spleen, since these organs are most commonly involved in either spontaneous or traumatic rupture. Extension of the incision cephalad must be made to visualize adequately the upper abdominal viscera. The subcapsular hematoma of the liver with rupture of the capsule is usually limited to the dome of the right lobe; however, this can occur elsewhere and a thorough exploration of both lobes and all surfaces of the liver should be made.

The loss of blood through the ruptured capsule is usually not massive, but rather slow and continuous, as is characteristic of liver injuries. For this reason the more simple methods of hemostasis should be attempted first and will frequently suffice. The use of absorbable hemostatic agent, such as Gelfoam and Oxycel, was employed successfully by Burton-Brown and Shepherd.[2] Another method is the application of topical pressure manually or by packing, as was used in the case reported by Rademaker[14] and in the present case. Links[12] attempted to control the bleeding using diathermy, but was unsuccessful, and resorted to packing the involved area with a flap of rectus muscle. Diathermy might suffice in an occasional case in which the bleeding area is small, but it has the disadvantage of causing an area of eschar with the development of subsequent necrosis and hemorrhage.

A useful adjunct to the above methods of hemostasis is manual compression of the vessels in the portal triad, which was employed in the present case. The maneuver effectively occludes the entire hepatic blood supply and may be used for periods up to 10 minutes without danger of liver necrosis. The most accepted method of hemostasis, particularly in the event of brisk hepatic hemorrhage and of failure of the more simple methods, is suture of the defect. This is accomplished by the use of large, blunt needles and a heavy absorbable suture. The adequate control of hemorrhage should be followed by drainage and by liver biopsy. Subdiaphragmatic collections of blood, necrotic hepatic tissue, and bile frequently accompany injury to the liver,

and by adequate drainage these complications may be avoided.

SUMMARY

This report includes the 21st case report of spontaneous rupture of the liver associated with pregnancy and a review of the literature.

The majority of cases have been multiparous women between the ages of 26 to 35 years. The disease has occurred in the second trimester, third trimester, and in the immediate postpartal period.

The paramount symptoms and signs correlate with the pathologic processes of hematoma formation in the liver followed by rupture through the capsule and subsequent hemoperitoneum. The common clinical picture is one of upper abdominal pain and tenderness, shock, and toxemia of pregnancy—frequently accompanied by eclamptic convulsions.

In this series of 21 cases there were 6 survivals and 15 deaths, representing a 71 per cent mortality rate. Only the 6 patients who were operated upon for suspected intra-abdominal hemorrhage survived.

The common pathologic finding in this disease is a large subcapsular hematoma of the liver, usually located over the dome of the right lobe, and accompanied by rupture of the liver capsule, which creates a hemoperitoneum. Microscopically, there is dissociation of liver cells and foci of lobular necrosis, with surrounding zones of hemorrhage.

The etiology of this disease remains obscure. Most authors agree, however, that the one predisposing factor is toxemia of pregnancy, which may cause an increased vascular fragility or alteration in blood coagulability. Other manifestations of hemorrhage in pregnancy complicated by toxemia and chronic hypertensive disease include abruptio placenta, cortical necrosis of the kidney, and hemorrhage into the adrenal glands and brain.

The successful management of the disease depends on the suspicion of it and on early operation. A cul-de-sac puncture is helpful in verifying the presence of a hemoperitoneum. Adequate blood replacement is necessary to correct the blood volume deficit. Conventional methods of hemostasis used for the successful control of hemorrhage from the liver are described. It is suggested that the adequate control of hemorrhage from the liver be followed by drainage and by liver biopsy.

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HYPOTHERMIC CIRCULATION WITH A TEMPERATURE REGULATING PUMP OXYGENATOR

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The advantages of internal hypothermia and extracorporeal circulation for cardiopulmonary bypass have been recorded by Gollan,[1, 2] Sealy and co-workers,[3, 4] and Zuhdi and associates.[5, 6] Gollan's original basic work is the most informative reference for those interested in the physiology of hypothermic perfusions. Along with increased enthusiasm for internal hypothermia, there has been more frequent use of perfusion of coronary arteries with cold blood to arrest the heart during normothermic perfusions.[7] The system has been simplified until little time or equipment is necessary to accomplish internal hypothermia by means of a pumpoxygenator.[8, 9] Our experience with this system for the correction of intracardiac defects, and also an account of clinical application of priming the system with 5 per cent glucose in water is here reported.

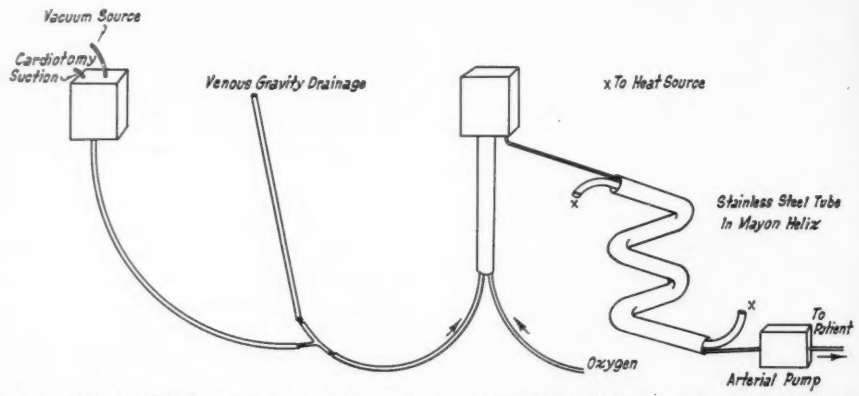

FIG. 1. This simplified apparatus, now in use for hypothermic perfusion, may be primed with 5 per cent glucose in water.

METHOD

Our apparatus (fig. 1) is comprised of a modified DeWall bubble oxygenator[10] with a double helical reservoir.[11] Blood from venae cavae cannulae and the cardiotomy suction[12] is drained by gravity directly into the base of the oxygen-blood mixing column. Temperature is controlled by countercurrent circulation of water through an inner stainless steel coil placed into the helical reservoir. Only 1 head of a Sigmamotor pump is necessary for the entire system, and this returns arterial blood to the femoral artery. Perfusion rates are 20 cc. per kg. body weight per minute; the highest flow being 1500 cc. per minute in a 92-kg. man. The priming volume is 300 to 1200 cc. of blood depending on the flow rate. More recently 5 per cent glucose in water has been used to prime the apparatus and ACD bank blood is given to replace that lost.

CLINICAL MATERIAL

Table 1 shows our clinical experience of open repair of cardiac defects in patients with the use of hypothermic perfusion. It is apparent there were no deaths in the repair of atrial septal defect, mitral or aortic disease, ventricular septal defect, and pulmonary stenosis. Of the 7 patients undergoing corrective operations for tetralogy of Fallot, 2 deaths occurred. The 1st of these was due to disruption of repair of ventricular septal defect; the other was a result of pulmonary complications on the 3rd postoperative day. In addition, 1 death occurred in a 71-kg.

man because of coronary occlusion and ventricular fibrillation, 30 hr. after repair of complete atrioventricularis communis defect, and 1 late death occurred 4 months after repair of atrial septal defect as a result of acute pancreatitis. We obtained 35 consecutive survivors in the midportion of the series. This attests to the clinical use of our apparatus.

TABLE 1

Defects repaired and results in hypothermic total body cardiopulmonary bypass

Defect	Cases	Death
Interatrial septal defect	12	0*
Interventricular septal defect	12	0
Pulmonary stenosis or I.S.†	9	0
Tetralogy of Fallot	7	2
Mitral disease	7	0
Aortic stenosis	2	0
Coarctation of base of aorta	2	0
Atrioventricularis communis	1	1

* One late death due to acute pancreatitis 4 months after surgery.

† Infundibular stenosis.

The low complication rate was also very encouraging. The only significant complications were transitory, partial heart block after repair of interventricular septal defects in 2 patients, and after repair of the defects in tetralogy of Fallot in 2 patients. Most patients required no more care than the usual thoracic surgical patient. There has been no evidence of hemorrhagic tendency, rewarming shock or any other untoward effect of perfusion or hypothermia.

There were 11 operations performed with hypothermia induced by internal and external cooling.[8] Temperature was controlled in 17 cases by the internal method, with the use of the stainless steel coil in the helical reservoir and stainless steel loops in the venous reservoir. Cooling and warming have been performed by the stainless steel helical coil in 24 patients. No appreciable difference in control of temperature has been apparent in any of these patients. Cooling occurred at the average rate of about 1°C. per minute; warming was somewhat slower depending upon the depth of cooling and length of perfusion.

TABLE 2

Data on 11 patients in which the extracorporeal circuit was primed with 5% glucose in water

Patient	Age	Weight	Perfusion Time	Diagnosis	Total Amount of ACD Blood Used during Open Heart Surgery	Plasma Hemoglobin Rise
	yr.	*kg.*	*min.*		*cc.*	*mg. %*
1	7	21	31	Pulmonary stenosis	575	8.4
2	7½	22.6	81	Interventricular defect	600	19.2
3	45	72	189	Atrioventricularis communis	2950	Not done
4	46	49	33	Interauricular defect	600	16.4
5	3	13.6	26	Interauricular defect	310	9.0
6	9	28.9	88	Interventricular defect with pulmonary hypertension	1700* 500†	8.3
7	2½	12.5	42	Pulmonary stenosis	400	9.6
8	10	38.9	62	Coarctation of base of aorta	1125	Not done
9	54	70	178	Mitral stenosis and mitral insufficiency	4750	45.8
10	21	35	82	Aortic stenosis	800* 250† 950‡	11.5
11	54	144	61	Mitral stenosis	2800	Not done

* Blood before perfusion (inferior vena cava tear).

† Blood during perfusion.

‡ Blood after perfusion.

DISCUSSION

It has been the objective of surgeons employing cardiopulmonary bypass to have simple, inexpensive, disposable, easily assembled, preheat sterilized, easily operated apparatus, with a low priming volume. There should be good oxygenation of the blood and, no hemolysis or acidosis should occur. We feel this system approaches this goal.

The entire apparatus may be assembled and primed in 30 minutes. The parts are inexpensive, are heat sterilized and those major portions in contact with the blood are disposable. One person can run the pump oxygenator and thermal regulating device. There has been a very low rate of hemolysis[11] even with prolonged periods of cardiopulmonary bypass.

The priming volume varies from 300 to 1200 cc. of blood or 5 per cent glucose in water. In the last 11 cases, 5 per cent glucose in water has been used and the blood lost at surgery has been replaced with ACD bank blood (table 2). There is a negligible amount of hemolysis with either blood priming or when the system is primed with glucose in water. If the latter method of priming continues to prove acceptable, a great step toward a practical system for all hospitals has been reached. Reference to table 2 reveals the low volume of bank blood used for each patient. This indicates considerable saving in typing and crossmatching and the small amounts needed do not deplete the source of donors in the community.

SUMMARY

An efficient practical system for hypothermic extracorporeal circulation is presented and the results in 52 cases reviewed.

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ADDENDUM

Priming of the apparatus with 5 per cent glucose in water has been performed in a total of 47 patients up to October 15, 1960. The amount of ACD bank blood used has been reduced to that lost at surgery, as the blood in the extra corporeal system is returned to the patient at the termination of the perfusion. This is accomplished safely by "chasing" the remaining blood from the system with 5 per cent glucose in water.

AN IMPROVEMENT IN THE TECHNIQUE OF CHOLECYSTECTOMY

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The standard technique of cholecystectomy may, as some contend, have reached its full development. However, surgeons experienced in gall bladder surgery will, I believe, agree that a difficult and crucial period in the operation is the ligation of the cystic duct and the cystic artery. It is difficult because it is troublesome to manipulate the hands into a position to make a secure tie and it is usually necessary to make the actual tie blindly. It is crucial because serious accidents may occur, and have occurred, in its employment.

When the gall bladder and its attendant structures present themselves with relaxed ease, any type of ligation of the cystic duct and artery is easy. Unfortunately, however, this happy circumstance does not occur in the presence of the usual pericholecystic pathology. Under these circumstances, even after meticulous exposure of the junction of the cystic and common duct, the placement of any type of ligation cannot be done with certainty because it is practically impossible to see the final position of the tie until after the first knot is tied and then inspected. Even with this inspection, it is not always easy or positive to ascertain whether the ligation has been placed too close to the common duct or has actually "tented" the common duct. Experiences by competent surgeons attest to this statement.

In addition to the troublesome aspects of using the ordinary ligation in the closure of the cystic duct, there is a real hazard in using this method of tying off the cystic artery. I personally have not experienced the accident but I know of 2 cases in which it did occur and I know it is a potential hazard in all instances.

The accident occurs when, as the first tie of the cystic duct is made, the ligation breaks and results in avulsion of the cystic artery from the hepatic artery, with all its obvious and unfortunate sequences for both the surgeon and the patient. A simple modification in technique, eliminating these real and potential difficulties and providing a safe and simple timesaver in the operation, should be welcome.

With the adoption of the neurosurgeon's metal clips to replace the silk, cotton or catgut ordinarily used in closing the cystic duct and artery, these difficulties have, I believe, been eliminated. The metal clip most commonly used is the 4-mm. (McKenzie) clip. This size clip is always satisfactory for closure of the cystic artery and is usually adequate for the cystic duct. Occasionally, however, the cystic duct is so widely dilated that this clip is too short. Under these circumstances the larger 7-mm. (Sugar) clip has been found desirable. In only 3 instances have I found the 7-mm. clip inadequate for a grossly dilated cystic duct. To accommodate these different sized clips, a clip holder has been fashioned so that both sizes are readily available on the same holder (fig. 1). I am convinced, however, that the clip holder shown is too long and would be cheaper and yet adequate if made to accommodate only 8 clips of each size instead of the 25 shown.

The clip applicator (fig. 2) borrows the basic style and size of the ordinary Mixter gall bladder forceps but is somewhat heavier in construction so as to eliminate any flexibility. The same instrument accommodates both the "standard" 4-mm. and the larger 7-mm. clip with equal positiveness. It has been found highly satisfactory in every respect.

For those unfamiliar with the use of metal clips, certain items are basic. To pick up the metal clip from the clip holder, the applicator forceps are first set at either the 4-mm. or the 7-mm. position, whichever is desired. The forceps are grasped near the jaws (specifically at the "lock") and firmly pressed over the clip that is resting on the clip holder. By this maneuver the clip is firmly seated and is ready for application. Compression of the forceps at this stage will bend the clip to make it useless; extension of the applicator will allow the clip to fall out. It is therefore important not to alter the position of the jaws of the forceps once the clip has been seated in position. A very useful suggestion, in

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FIG. 1. Clip holder (V. Mueller & Co.) for 4-mm. and 7-mm. clips

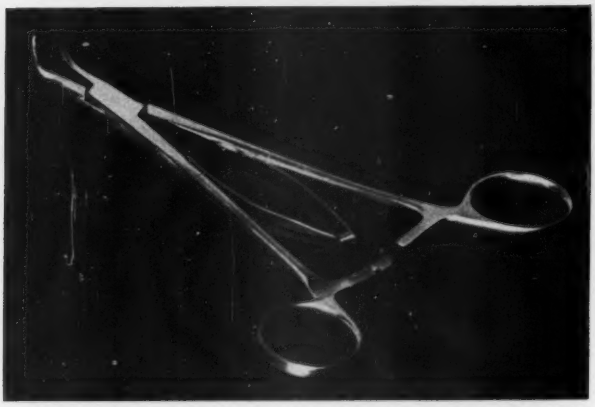

FIG. 2. Clip applicator (V. Mueller & Co.) for use in gall bladder surgery

this regard, is that the assistant maintain the grasp of the applicator at the "lock", not only as the clip is being seated, but also during the process of handing the applicator to the surgeon. If this maneuver is attempted while holding the forceps at its rings, it is difficult to prevent altering the position of the applicator jaws and subsequent displacement of the clip. Being careful, again, not to alter the position of the jaws of the forceps, the surgeon firmly pushes the apex of the clip against the duct or artery at the desired location, and then closes the applicator with sufficient pressure to fix the clip in position. The release is made by simply opening the applicator forceps in the usual manner. The procedure is quick, simple, and positive.

We have found that closure of the cystic duct and artery by metal clips has simplified the procedure and made it quicker and safer to a degree that can be realized only by experiencing the maneuver. As previously stated, it is a distinct advantage to the surgeon and the patient to visualize clearly and control accurately the closure of the cystic duct and its artery without the hazards of blind tying or broken sutures and with a saving of many important minutes. Surgeons who have seldom or never used metal clips may have an instinctive fear of their dependability. This fear is a result of inexperience. Neurosurgeons have, for many years, used metal clips for the closure of arteries and other structures just as vital as the cystic duct and cystic artery, and they continue to use metal clips with confidence and satisfaction. It has been demonstrated innumerable times that once a metal clip is properly in place it will not and cannot be displaced. After the cystic duct is closed with a metal clip, there is no more tendency for the clip to slough into the common duct than there is for cotton, silk or catgut to do so. We, at present, have 42 cases to substantiate this statement.

This method is presented as an improvement in the technique of cholecystectomy which, in our experience of over three years, has been an important time saver, has been safe, and is much more simple than the time-honored method of ligature. The surgeon who has never used metal clips will be helped by consultation or practice

to learn the few simple maneuvers necessary for the proper application of metal clips, just as he earlier learned the proper application of a ligature. It is interesting that several of our colleagues have used the applicator and the metal clips in other types of abdominal surgery with considerable satisfaction.

It is our belief that the method described is an improvement in the technique of cholecystectomy and may even find other spheres of usefulness in other types of abdominal surgery.

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SPONTANEOUS RUPTURE OF THE SPLEEN IN INFECTIOUS MONONUCLEOSIS: A CASE REPORT

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Spontaneous rupture of the spleen in infectious mononucleosis is a rare catastrophe in a relatively benign and common disease. Because of its unusual occurrence and because of the necessity of prompt diagnosis and surgical treatment, if the patient's life is to be saved, the following case is reported.

CASE REPORT

History. A 37-year-old white man was admitted to Crawford W. Long Memorial Hospital because of weakness and fainting. His past history was noncontributory except that he had been observed by an internist (R. A. H.) during the preceding 3 years. During that time the patient had tonsillitis, mumps and subdeltoid bursitis, all of which responded well to appropriate therapy. His present illness began with chills, fever, muscular aches and diarrhea, approximately 2 weeks before admission to the hospital. During the 1st week of his illness the symptoms were rather mild, and he did not consult a physician. However, 10 days before admission to the hospital he was examined in the office of R. A. H. and was found to have the above symptoms less diarrhea. The temperature then was 99.6. Physical examination at this time was not remarkable except for enlarged axillary lymph nodes. The diagnosis of a probable viral infection was made, and the patient was placed on symptomatic treatment.

In the morning of the day of admission to the hospital the patient arose at his usual time and noticed slight left upper quadrant pain while shaving. This persisted and was accompanied by slight weakness, and as he rode to work in an automobile he became progressively weaker and finally fainted. He was taken to the company first aid station, examined by a physician, and sent home.

He was examined at home by his personal physician and was found to be very weak and pale. His blood pressure was 80/60, pulse 110. Other significant findings were limited to the abdomen which was found to be slightly distended and soft with slight tenderness and muscle spasm more in the left upper quadrant. The spleen and other organs, or masses, were not palpable. Rectal examination was negative. The patient was immediately transferred to the hospital.

Laboratory findings. Red blood cells, 4,000,000; hemoglobin 11.1 gm. (72 per cent); white blood cells, 6400; differentiated segmented cells, 50; stab cells, 1; lymphocytes, 49; monocytes, 0; urine examination was normal. X-rays of the chest were normal. Those of the abdomen revealed no evidence of air in the peritoneal cavity. There was an area of increased density in the left upper quadrant suggesting an enlarged spleen with compression of the gastric air shadow, medially. The intestinal gas pattern was consistent with mild paralytic ileus.

Shortly after the x-ray studies had been completed, peritoneal aspiration was done in the left flank under local anesthesia with an 18-gauge needle. A free drip of dark venouslike blood was obtained. The diagnosis of splenic rupture from infectious mononucleosis was made and the patient was prepared for immediate surgery. Two pints of blood were given rapidly by positive pressure preoperatively and 4 pints were administered during surgery. The operation was carried out under general, endotracheal anesthesia through a left subcostal incision. The peritoneal cavity was filled with dark blood. Approximately 1 liter was suctioned off before the spleen could be adequately visualized. It was found to be considerably enlarged, and friable with a long capsular tear. From this tear there was a constant ooze of blood. Beneath the capsule there was an extensive soft hematoma. The vasa brevia and pedicle were clamped, divided, and ligated with 2-0 silk, and the spleen was removed. After this, the condition of the patient steadily improved. A Penrose drain was left beneath the left diaphragm and brought out through an incision in the left flank. The remainder of the free blood and clots were removed from the pelvis; the right paracolic and subphrenic spaces and the abdomen were closed anatomically in layers with silk. The operating time was 90 minutes. The postoperative course was uneventful. Heterophil antibody titer on the 2nd postoperative day was 1,256. (A titer of 1,128 is diagnostic in this hospital.) The patient was discharged from the hospital on the 8th postoperative day.

PATHOLOGIC EXAMINATION

Gross description. The specimen, submitted in formalin, consists of a totally removed spleen measuring 15 by 16.5 by 4 cm. and weighing 630 gm. The external surface is dark red and is covered by large blood clots. The capsule is lacerated with some disruption of parenchyma. Sectioning has revealed a soft, dark red pulp with large hemorrhagic areas.

Microscopic description. Although the capsule is largely absent, the remaining portions are not unusual. There are areas of recent capsular and subcapsular hemorrhage with heavy infiltrates of acute, chronic inflammatory cells as well as large numbers of erythrocytes. The hemorrhagic areas extend deeply into the splenic pulp, widely separating the follicular structures. There is considerable necrosis of the splenic pulp. The follicles themselves are not particularly prominent, but they are somewhat enlarged, showing maturation of lymphocytes at the periphery. In the periphery of occasional follicles some of the lymphocytes have irregular nuclei with a tendency toward lobulation. Other noticeable features are small cells with centrally located pyknotic basophilic nuclei and peripheral rims of eosinophilic cytoplasm, large areas of necrosis, infiltrates of polymorphonuclear leukocytes and considerable amounts of hemosiderin pigment in the sinusoids.

These changes present evidence of rupture of the spleen with focal hemorrhage throughout the pulp. Specific changes due to infectious mononucleosis are not apparent with the exception of some scattered, somewhat atypical lymphocytes.

Pathological diagnosis. The spleen was ruptured.

Discussion. This case illustrates several points which are worthy of comment. The laboratory diagnosis of the disease was not made until after the spleen had ruptured and the patient had undergone surgery. Before hospitalization, the patient had been seen only once in the office and he then complained of malaise and fever for which symptomatic treatment was given. Rupture of the spleen occurred apparently 16 days after the onset of symptoms and was not precipitated by any known trauma. The patient was questioned quite carefully on this point. The diagnosis was suspected when he was found to be in shock with signs of an acute surgical abdomen. Peritoneal aspiration was of great value toward making a rapid decision to operate.

This case is probably typical of those seen by the internist and general practitioner. In a busy practice many patients are seen with low grade fever and malaise. It is not economically practical to run unlimited laboratory tests in order that a diagnosis may be made in each instance. Certainly, however, among those patients in whom a diagnosis of infectious mononucleosis is established, it would seem judicious to avoid vigorous palpation over the splenic area and to restrict their activity for a reasonable period of time. It would also be wise to advise such patients that any acute pain in this area, particularly when accompanied by weakness and fainting, should be regarded as an emergency for which prompt medical aid should be sought.

SUMMARY

A case of spontaneous rupture of the spleen due to infectious mononucleosis is presented. Peritoneal aspiration was of great help in making the correct diagnosis and instituting prompt surgery.

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IS CANCER OF THE RECTUM WORTHY OF THE SURGEON'S EFFORTS?

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The title of this article is unusual, in that it seems to question the general impression that surgeons advise some type of surgery as the best method of treatment for most malignancies arising in this area A review of 178 patients with cancer of the rectum, and one case in particular, has tended to cast some doubt on this assumption.

CASE REPORT

A white man in his late 50's (CL-87,140) saw his physician for an uncomfortable feeling in the rectum. A rectal digital examination was done and no abnormalities noted. No other studies were carried out.

One year later he again returned to his physician with similar complaints, at which time it was thought there might be something unusual present and, after reference to a proctologist, a biopsy was taken. The patient was told that he had a cancer but at the same time his physician said that he would not operate on him, but, if he insisted on surgery, he would send him to a "butcher" in another city. After 6 months, about 1½ years after the onset of the symptoms, he was seen by us. He now had secondary anemia and a large, friable, bulky mass, accessible to the tip of the finger, which, on biopsy, showed adenocarcinoma. A palliative excision to prevent further hemorrhage, tenesmus, and possible obstruction, was performed with great difficulty. Residual tumor was left along both ureters, and many enlarged periaortic lymph nodes were noted. Since this surgical procedure was performed 3 months ago, local recurrence in the abdominal wall has necessitated radical local excision. The patient is alert, cooperative, quite intelligent, and pleasant; accepts his present status very well, manages his colostomy well. He knows that he cannot be totally relieved, but wonders why intervention was not undertaken at an earlier date. His terminal care undoubtedly will be difficult, probably associated with a large ulceration of the abdominal wall with local recurrence in the region of the sacral plexus, associated with pain which will probably be quite difficult to control.

Why at times does confusion and pessimism intervene to plague the attending physician and to prevent energetic, intelligent treatment of cancer patients, in particular, those with cancer of the rectum? One obtains a part of the answer by reflecting upon the fact that no satisfactory set of principles exists today to govern the treatment. Is the standard radical mastectomy for cancer, presumably limited to the breast, the treatment of choice, or is simple mastectomy combined with external irradiation just as satisfactory? Furthermore, is there any difference in the ultimate outcome, whether or not the operation is carried out by skilled surgeons accustomed to working in this area, or is it the same when it is done by the occasional operator? Some of these questions, along with others, were touched upon in a recent article by Skandalakis.[1]

The confusion regarding the selection of the best method for the surgical treatment of cancer of the rectum may not be quite as great as that in cancer of the breast, but pessimism regarding the ultimate outcome is perhaps even greater in this area; certainly there is a very poor understanding among lay people and frequently also among graduate nurses, and to a lesser extent among physicians, of life with a permanent, so-called curative, sigmoid colostomy. How often has one heard a patient say, "I would rather be dead than try to live with a colostomy." This remark tends to indicate a presumption that the patient will be cured of the cancer of the rectum, only to live "miserably" with a colostomy. Such a remark indicates an attitude, and a lack of understanding, that may do real harm. It takes no consideration of the subsequent events which transpire in the life of the patient with adenocarcinoma of the rectum, who fails to have some type of surgery, as it is well known that other modalities of therapy, such as radiotherapy and chemotherapy, have little to offer the patient, and that the escape from life in such

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instances is an exceedingly trying ordeal for the patient, as well as for those charged with responsibility of his terminal care.[2]

As before implied, the remarks in this article will be based largely on the experience gained by managing 178 patients with cancer of the rectum and rectosigmoid, from January 1, 1947, through December 31, 1959. Case numbers of illustrative patients will be recorded and abstracts of these will gladly be supplied to the interested reader.

Perhaps it would be well to reflect upon the natural course of malignant disease of the area under consideration, in those instances in which its course is not altered by some type of therapy. Such a task presupposes that one record his understanding of the pathologic physiology involved, and relate it to the clinical course.

Regardless of whether or not the physical structure upon which the cancer arises is first that of a polyp, or the surface epithelial cells of the mucosa, is not a fundamental point. As these cells divide and grow they do so at different rates of speed in different patients, and perhaps at times at varying speeds in the same patient, the cells invading the local adjacent tissues, such as the muscular wall. As the local spread continues, the blood supply in the center may be compromised and result in ischemia, necrosis, infection, ulceration, and finally hemorrhage. In addition to spread by direct extension and lymphatic invasion, sooner or later some of the malignant cells will enter blood vessels, usually veins, to travel along the portal venous drainage system, there to be filtered out by the liver and in many instances to set up viable metastases.

The physical appearance of the tumor apparently has little to do with this mysterious force which initiates lymphatic and hematogenous spread. As time elapses and if the host survives, the local growth increases in size and if sufficiently great in physical dimensions, due to its location, it may cause obstruction of the bowel. Long before this occurs, however, undoubtedly bleeding from ulceration, associated with secondary infection will have occurred. These changes will be associated with alterations of the physiologic movements of the bowel, usually producing diarrhea which will contain some blood and some mucus and be associated with symptom of tenesmus. Unaltered in its course, the tumor goes on to invade locally adjacent structures such as the internal genitalia in the female, and in both sexes, the ureters, the urinary bladder, and the major nerves of the pelvis. In those instances where the new growth is near the anal orifice, or in which perhaps the proximal lymphatics are blocked, spread to the inguinal nodes in both the male as well as the female occurs. (Mr. R., CL-58, 572 and Mrs. L. W. R., CL-1881).

These relatively local changes which have been described are associated with well known systemic changes such as weakness, and perhaps abdominal cramps with loss of appetite.

There will be those who will ask the question, "How long does it take these changes to occur?" In the light of our present understanding of this disorder no exact answer can be given to this question. It should be emphasized, however, that the usual patient with adenocarcinoma of the rectum has a disease which pursues a comparatively indolent course, this being true in both the young as well as the old individual. To illustrate, case CL-88,727, a 35-year-old white man, had rectal bleeding for 1½ years and on proctosigmoidoscopy was noted to have internal and external hemorrhoids. A hemorrhoidectomy was done. Bleeding persisted and a second hemorrhoidectomy without benefit of barium enema was done. After the patient had been ill, judged by the symptomatology, for about 1½ to 2 years, an adenocarcinoma of the rectosigmoid colon which had invaded the muscular wall but not the regional nodes, was removed with prompt cessation of the rectal bleeding. A second case, Mr. L. D. M., CL-66,190, age 82, had severe cardiovascular disease with congestive heart failure and an adenocarcinoma of the rectum accessible to the tip of the examining finger. His life expectancy, due to his systemic disease, was thought to be short. However, at the end of 1½ years, severe hemorrhage with tenesmus and impending obstruction necessitated combined abdominoperineal resection.

The life history of other malignant new growths of the rectum and rectosigmoid colon may differ somewhat from that of the above described adenocarcinoma.

Surgery remains the best method for treating patients with cancer in this area, unless it be contraindicated by widespread metastases, marked local fixation, or serious concomitant systemic disease. In the face of each or all of these, with due care, one may use various surgical methods to improve the lot of the patient,

oftentimes bringing great symptomatic relief, but rarely with total alleviation. In general, the method of choice is radical removal by a selected technique. The excision should encompass the primary growth and its adjacent lymph node-bearing area. The surgeon should be prepared to remove unhesitatingly locally invaded structures, such as segments of the small bowel, the internal genital tract structures in the female, and portions of the urinary bladder. This is not mutilation. The posterior lobe of the prostate gland with other secondarily invaded areas such as the buttocks may require excision, even though this may later require split thickness skin grafting for healing. The surgeon must thoughtfully utilize varying techniques and approaches, combining them at times with staged procedures (CL-82,856). He must understand that each patient's problem must be tailored to fit his own peculiar local, as well as systemic requirements. A persistent, conscientious, effort should be exercised to remove at least the primary growth, thereby preventing further blood loss, anemia and tenesmus. Colostomies, even in the presence of high grades of obstruction, without removal of the primary neoplasm should be scrupulously avoided. Under such circumstances the physiologic irritability of the bowel, associated with diarrhea, make terminal care difficult. In these instances a great deal of comfort can be secured by liquid diets, perhaps intermittent gastric suction by the nasogastric route, or by tube gastrostomies. Suture of the severed end of the colon to the abdominal wall skin hastens the maturation of the colostomy, thereby obviating loose stools in the early postoperative period.

Radiotherapy may bring considerable regression in the primary tumor, as well as in its metastases, thereby bringing considerable comfort to the patient. Chemotherapeutic agents such as Cytoxan (Mead Johnson & Co.) occasionally cause rather dramatic regression of these cellular tumors.

The total care of these patients throughout their entire illness requires a great deal of thought and ingenuity. In general, it is felt that these patients should be told the truth, but only that portion of the truth which will be helpful to them. Certainly a cheerful smile is indicated. Such methods as chemotherapy, although occasionally causing some uncomfortable side effects, lend hope to the patient, an emotion which should never be taken from him.

Our experience encompasses 79 radical combined abdominal-perineal procedures for cancer in all types of patients and in all age groups, with a mortality of 8 per cent. In this group of 79 patients, 36 were 65 years of age or older. Three of these died in the hospital. It should be emphasized that the procedure can be safely carried out, even in bad risk patients, provided they are brought to optimum condition by careful preoperative preparation. One has the feeling that it is not fear of the operation or of the surgery, but rather the fear of life with a colostomy which causes many patients, as well as physicians, to procrastinate. Suture of the severed end of the colon to the skin edges hastens maturation of the colostomy and the subsequent care of this can be made much easier by omitting cleansing enemas, which are time consuming for the patient, and which tend to cause irritability of the remaining colonic segment with perhaps frequent evacuations of gas or stool. With due care, many patients have cause to wonder why mother nature placed the anus in its usual position, rather than on the abdominal wall.

SUMMARY

Cancer of the rectum is worthy of the surgeon's efforts. Life with a permanent colostomy is compatible with an almost normal existence.

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THE COMPLICATIONS OF SURGICAL WOUNDS

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All surgeons, irrespective of their individual interests, deal with one problem in common: operative wounds. The complications of surgical wounds, namely, seroma, hematoma, bacterial infections, and disruptions, continue to remain important deterents to rapid postoperative convalescence. Many factors may be involved in such complications; notably, nutritional status, anesthesia, suture material, dead space, infection, and antibiotics. The development of antibiotic therapy over the past decade has been helpful in reversing established infections, especially when systemic in nature, but there is scant evidence that antibiotic therapy is of value in the prevention of bacterial wound infections. On the contrary, evidence is accumulating that prophylactic antibiotics may result in the development of resistant flora for which appropriate therapy is unavailable. In order to assess objectively the influence of many of these factors on the complications of surgical wounds on a general surgical service, the following study was carried out.

MATERIALS AND METHODS

One thousand consecutively operated cases from the General Surgical Wards of the University Hospital in Oklahoma City were studied. Antibiotics, either preoperatively or postoperatively, were ordered at the discretion of the operating surgeons. There was no preoperative preparation of the incisional site other than shaving. At the time of operation, the area was scrubbed for 5 min., dried with a sterile towel, and draped. Postoperatively, sterile dressings were applied to the wound. These were removed after 48 hr., after which the wound was left exposed, except that drained wounds were dressed daily and left covered until 24 hr. after the drain had been removed.

Appropriate observations were made in each case and recorded on a protocol sheet especially designed for the study, and attached to the chart of each patient. When follow-up was complete, the data were coded and transposed to business machine punch cards for analysis. In the event that an operative wound was unavailable for postoperative study (death of the patient, or early postoperative amputation, or excision of the original surgical wound) the case was eliminated from the study.

RESULTS

The 1000 cases included 533 men and 467 women with an age distribution from newborn to 80 years. One third of the patients were over 60 years of age (table 1). A wide variety of general surgical operations was involved (table 2). Careful postoperative observations were made to determine: (1) the incidence of wound infections in clean and contaminated cases, (2) the incidence of hematoma, (3) seroma, (4) incidence of wound disruptions, (5) the effect of drains on the above complications, and (6) the effects of antibiotics. The wounds in this study were considered as either clean or contaminated. Clean wounds are self-explanatory. Contaminated wounds were defined as wounds in which frankly purulent material was contacted, or when contaminated areas were opened or transected, such as bowel, biliary tract, etc.

Tables 3 and 4 summarize the incidence of wound infections among 537 clean surgical wounds. Fifty-one patients received preoperative antibiotics (table 3). One of the wounds was packed open, leaving 50 wounds in which infection could occur. Two infections (4.0 per cent) occurred in this group. Among 486 clean cases not receiving preoperative antibiotics, four wounds were packed open, leaving 482 wounds available for infection. Fifteen occurred, an incidence of 3.1 per cent. There was one pulmonary complication when preoperative antibiotics were given, and two pulmonary complications when they were not used.

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TABLE 1

*Age distribution of 1000 cases**

Age Group	Number of Cases
0– 9	19
10–19	63
20–29	79
30–39	119
40–49	159
50–59	238
60–69	165
70–79	128
80–89	30

* Men: 533; women: 467.

TABLE 2

Type of operations

Type	Number of Cases
Congenital	19
Inflammatory	298
Traumatic	23
Circulatory	132
Static mechanical	196
Neoplastic—cystic	330
Other	2
Total	1000

TABLE 3

Wound infections in 537 clean cases

Wounds	Preop. Antibiotic Used	Preop. Antibiotic Not Used
Total	51	486
Wounds packed	1	4
Wounds available	50	482
Complications		
Infections	2 (4.0%)	15 (3.1%)
Pulmonary complications	1	2

Table 4 reveals that there were 13 wound infections among the available clean wounds when postoperative antibiotics were used, an incidence of 9.0 per cent. In 387 available clean wounds among patients not receiving postoperative antibiotics, there were four wound infections (1.0 per cent).

Table 5 summarizes our experience with 463 contaminated cases. Postoperative antibiotics were used in 247. There were 27 wound infections among the 226 sutured wounds (11.9 per cent) in this group. No postoperative antibiotics were used for 216 patients, 17 of whose wounds were packed open. There were 10 infections among the 199 remaining, an incidence of 5.0 per cent.

Drains were used in 323 operations. These drains emerged through either the primary incision or through separate stab wounds. Table 6 reveals that there were 150 instances in which the drain emerged through the primary incision. Eighteen (12.0 per cent) wound infections oc-

TABLE 4

Wound infections in 537 clean cases

Wounds	Postop. Antibiotics Used	Postop. Antibiotics Not Used
Total	148	389
Wounds packed	3	2
Wounds available	145	387
Infections	13 (9.0%)	4 (1.0%)

TABLE 5

Wound infections in 463 contaminated cases

Wounds	Postop. Antibiotics Used	Postop. Antibiotics Not Used
Total	247	216
Wounds packed	21	17
Wounds available	226	199
Infections	27 (11.9%)	10 (5.0%)

TABLE 6

Complications in 323 drained wounds

Wounds	Incision Drainage	Stabwound Drainage
Total	159	164
Wounds packed	9	0
Wounds available	150	164
Complications		
Wound infections	18 (12.0%)	14 (7.6%)
Seromas	5 (3.3%)	4 (2.4%)
Hematomas	4 (2.6%)	1 (0.6%)

TABLE 7

Complications in 677 wounds not drained

Total	677
Wounds packed	34
Wounds available	643
Complications	
Infections	22 (3.4%)
Seromas	7 (1.0%)
Hematomas	11 (1.7)%

TABLE 8

Wound infections: elective vs. emergency operations

Operations	Number of Cases	Wound Infections
Elective	934	48 (5.1%)
Emergency	66	6 (9.1%)

curred. Stab wound drainage was used 164 times with 14 infections (7.6 per cent). The occurrence of hematoma and seroma was noted to be less frequent when stab wound drainage was used. As anticipated, nondrained wounds (both clean and contaminated) were less apt to become infected, there having been 22 infections (3.4 per cent) among the 643 unpacked wounds (table 7). Note also that the appearance of hematoma or seroma is about the same for nondrained wounds as for cases drained through stab wounds.

Complete wound disruption occurred 4 times among the 1000 cases. Three of these wounds had been closed with layer silk technique, 1 of which also had wire retention sutures. The other wound had been closed with buried, interrupted wire sutures. None of these wounds had been drained through the primary incision, although 2 had had stab wound drainage. One factor, recorded in common to 3 of the 4 disruptions, was a strenuous extubation at the completion of the endotracheal anesthetic.

Table 8 reveals that wound infections occurred almost twice as frequently among patients operated on an emergency basis as among patients undergoing elective surgery.

DISCUSSION

Although a wound complication is the end result of many interrelated factors, ultimately, the surgeon who uses gentle operative technique, attends to careful hemostasis, and leaves no dead spaces, will be rewarded with the least incidence of wound difficulties. This study of 1000 operative cases indicates this clearly. At the same time, this review has been helpful in demonstrating the type of setting in which wound complications are somewhat more prone to appear.

First, consider the role of antibiotics. These agents have been added to the armamentarium of many surgeons, with the hope that their use might prevent the appearance of bacterial complications in surgical wounds. This practice has now extended to the use of antibiotics on an exclusively prophylactic basis. It is becoming obvious that their use offers no real protection against the appearance of a wound infection.[1-3, 5]

In our series, when antibiotics were used preoperatively the incidence of wound infection was greater than when they were not given. This cannot be interpreted as indicating that the use of antibiotics preoperatively predisposes to the appearance of a wound infection, since the indication for which the antibiotic was given is not always clear. It does indicate emphatically, however, that the use of the antibiotic, irrespective of the reason, did not prevent the appearance of wound infections among those receiving such treatment. A similar situation occurred when antibiotics were given postoperatively. Our experience indicated an incidence of wound infection nine times greater among patients who received antibiotics postoperatively even if only in clean surgical cases. Again, it is tempting to assume that the use of antibiotics following operation in clean cases predisposed to the appearance of a wound infection. However, the indication for the use of antibiotics is again not necessarily clear. The conclusion which can be stated with certainty, however, is that the administration of antibiotics during the postoperative period following a clean surgical operation in no way influenced the incidence of infected operative wounds. That a similar conclusion can also be reached for contaminated surgical cases is evident from our experience with 463 such cases summarized in table 5.

Garrod[2] states that the proportion of misused antibiotics in the United States is as high as 95 per cent. The objection to such misuse is not merely that it is wasteful, or that it hastens the

appearance of resistant bacteria, but it can also be expensive, and positively and directly harmful. Penicillin sensitivity, eighth-nerve deafness due to Streptomycin, bone-marrow depression with Chloramphenicol, the liver toxicity of the tetracyclines, and especially the near-lethal enterocolitis, serve as constant reminders of this hazard.

The indications for drainage, at the time of operation, vary considerably. The fine review by McLaughlin and Schilling[4] in this regard, is noteworthy. At the same time, a drain may be the source of some difficulty involving the surgical wound. Our study indicates that the incidence of infection is considerably higher among drained wounds than nondrained wounds. This is expected since the indication for drainage, in many instances, is the presence of established infection. On the other hand, it should be noted that the incidence of infection was decidedly less in those instances in which the drain emerged through a separate stab incision rather than the primary incision. It should also be noted that nonbacterial complications of the wound, such as seroma and hematoma, were considerably greater among the cases in which a drain emerged through the primary wound than those in which there were nondrained wounds or stab wound drainage.

The problem of wound disruption is particularly interesting. Many contributions to the surgical literature have been made on this subject. Although there is general agreement that the nutritional status of the patient, the factors involved in wound healing, the selection of suture material, the placement of incisions, etc., are important, it has been universally difficult to determine those factors shown in common by all wound disruptions. Indeed, it is not likely that any single factor is universally present. Our experience emphasizes one factor which is not ordinarily stressed in these reviews. This is the observation that the setting for a wound disruption may occur on the operating table at the time an endotracheal tube is removed. It is well known that the patient may strain, cough, and buck during this maneuver, to a degree that is not approached postoperatively when the patient is awake and conscious of pain. We recorded three instances of four disruptions in which a difficult extubation was encountered. Although Rosemond[6] places much emphasis on the type of wound and the selection of suture material, our wound disruptions could not be attributed to such factors.

SUMMARY

1. A total of 1000 consecutive surgical cases have been reviewed and studied with respect to the wound problems encountered.

2. The use of antibiotics prior to operation in clean surgical cases did not influence the incidence of wound infection in any way.

3. The use of antibiotics during the postoperative period did not change the incidence of wound infection in either clean or contaminated surgical cases.

4. The use of drains at the time of surgery was associated with an increased incidence of infection, seroma, and hematoma of the surgical wound. Stab wound drainage appeared to offer greater protection against these complications than drainage through the primary wound.

5. A total of 75 per cent of our wound disruptions were associated with a difficult extubation following endotracheal anesthesia.

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HERNIATED LUMBAR DISC—A SURGICAL EMERGENCY*

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There is a type of herniated lumbar disc that differs clinically from the "usual" herniated disc and constitutes an acute surgical emergency Although, ordinarily, a herniated disc protrudes to one side or the other and produces signs and symptoms in the ipsilateral leg, a disc will occasionally herniate in the midline, producing compression of the S2, S3 and S4 roots. Such sacral root pressure may result in saddle and genital sensory loss, urinary and perhaps bowel incontinence, and in the male, often with impairment in ejaculation and inability to obtain or maintain an erection. We choose to call this problem of lower sacral root compression intraspinally the *sacral syndrome.*

The lumbar disc that herniates and produces a sacral syndrome usually has, also, the signs and symptoms seen with an ordinary disc herniation. Thus, they may show, in addition to the sacral syndrome, "back signs", "sciatic signs" and perhaps additional "localizing neurologic signs".

The back signs and symptoms consist of back pain, limitation of back motion, loss of normal lordotic lumbar curvature, scoliosis with paraspinal spasm, and perhaps pressure over L4 or L5 will reproduce the radicular pain, if the herniated disc is at that level.

The sciatic signs most often found consist of sciatic tenderness, limitation of straight leg raising and leg pain production with neck flexion. Pain produced in the affected hip or leg area with straight leg raising on the opposite side is sometimes present, and this is suggestive of lumbo-sacral root pressure.

The localizing neurologic signs in addition to the sacral syndrome will depend upon the level of the disc herniation. The sacral roots in the midline can be compressed by any midline mass lesion at or beneath the level of the conus medullaris. When such compression is caused by a disc herniation, the disc most frequently the offender is at the L5-S1 intervertebral space level. However, sacral root compression can result from disc herniations at the L2-L3, L3-L4 or L4-L5 intervertebral levels, and the specific localizing signs then present will depend upon the exact level of the involvement. At the L2-L3 and L3-L4 intervertebral levels, quadriceps weakness, decrease or absence of the patellar reflex and decrease in sensation over the anterior portion of the thigh are most commonly found. With herniated discs at these levels there is a tendency for the radicular pain to be located primarily over the anterior thigh. At the L4-L5 intervertebral level, the patellar or Achilles reflex may be decreased or absent and weakness of the dorsiflexors of the foot or of the extensor hallucis may occasionally be found. Rarely quadriceps weakness may be present. L4-L5 discs are more often the "silent disc" type as far as signs are concerned. For some unexplained reason, L4-L5 discs are prone to produce radiation of pain into the groin on the affected side. Sensory decrease along the dorsomedial aspect of the affected foot can usually be expected. The disc herniation at the L5-S1 level typically produces localizing neurologic signs including weakness of the extensor hallucis and perhaps the dorsiflexors of the foot, a decreased or absent Achilles reflex and a decrease in sensation over the dorsolateral aspect of the involved foot.

Unfortunately, we as neurosurgeons, do not see most of these cases of herniated lumbar disc with sacral syndrome till after they have been given a trial of "conservative treatment". Once the diagnosis in this type of problem has been suspected, the patient should promptly have a myelogram. This is done not only to localize accurately the level of the lesion but to help rule out a cauda equina or conus medullaris tumor. Laminectomy should then be carried out that same day. The surgical approach for a herniated disc causing a sacral syndrome is essentially the same as for the usual lumbar disc herniation. However, the disc producing a sacral syndrome must be at least partially centrally located, and not infrequently they are so large that they produce bilateral leg pains and bilateral localizing

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signs in the legs. Unless a massive, totally extruded disc is found through the usual semihemilaminectomy approach on one side, a similar approach should be made on the opposite side also. The urgency of surgery in such cases cannot be overemphasized, for even with prompt surgical intervention, return of function will not always occur.

We have selected three typical cases of lumbar disc herniation with resulting sacral syndrome for presentation.

CASE REPORTS

Case 1

History. C. N., 34-year-old male sheep shearer, with a 1-year history of back pain with radiation into the left leg for 10 months. He had worn a back brace for 3 months before our examination. He stated he had noted progression of numbness of the legs for 3 weeks with a tendency to bladder retention. The patient had also been treated with 4 days of traction before our consultation.

Physical findings. (1) Back signs: moderate list to left; loss of normal lordotic lumbar curvature; forward bending to only 15°; bilateral paraspinal spasm. (2) Sciatic signs: straight leg raising to only 25° bilaterally; neck flexion produced leg pains; suggestive sciatic tenderness. (3) Neurologic signs: (a) Motor: moderate weakness of left gluteals and ventro flexors in left foot; weakness of dorsiflexors in feet, the left foot being weaker than the right one; rectal tone, poor. (b) Sensory: Slight genital and saddle hypalgesia. (c) Reflexes: patellar reflexes absent bilaterally; Achilles reflexes hypoactive.

Diagnostic impression. Massive disc herniation *versus* cauda equina tumor.

X-rays of lumbosacral spine. Noncontributory.

Myelogram. Complete block L4, extradural type defect.

Surgery. Modified laminectomy with removal of a large partially extruded disc L4-L5.

Recheck examination 3 years postoperative. No pain, leg strength improving, bladder control satisfactory, difficulty with propulsive force in bowel movements and ejaculation slow. Examination showed: forward bending to 80°, moderate weakness of left calf muscles, hypoactive patellar reflexes, Achilles reflex absent on left, perianal hypalgesia right and also dorsolateral aspect of right foot.

Case 2

History. C. H., 39-year-old male stockman and rancher, with intermittent episodes low back and left leg pain for 17 years after an auto accident. He had severe attack with some urinary retention 1½ years ago, but catheterization was not required. He had a 3-month history of constant pain in his left thigh. He developed very severe pain in the left leg 11 days before admission, and 5 days before admission, complete urinary retention, requiring catheterization, appeared. Some rectal incontinence was declared during recent weeks if cathartic was used. He complained also of a lack of feeling in the saddle area, genitalia and left leg.

Physical findings. (1) Back signs: forward bending to only 30°, moderate paraspinal spasm, deep pressure over L5 causing left leg pain. (2) Sciatic signs: straight leg raising 55° on right and 35° on left. (3) Neurologic signs: (a) Sensory: marked hypesthesia and analgesia saddle and genital area. (b) Reflex: right Achilles reflex decreased and left Achilles reflex absent.

Diagnostic impression. Massive disc herniation L5-S1.

X-rays lumbosacral spine. Some reduction L5-S1 interspace.

Myelogram. Complete block below L4-L5 disc space.

Surgery. Modified laminectomy with removal of huge herniated disc L5-S1.

Recheck examination 10 months postoperative. Patient stated he had no pain whatsoever, but had bowel and bladder incontinence; ability to obtain erection greatly impaired and sexual sensation greatly decreased. Examination showed: forward bending to 80°, moderate weakness of dorsiflexors in left foot, hypalgesia lateral aspect left foot, marked hypalgesia of saddle area with total anesthesia scrotal area, rectal tone poor.

Recheck examination 5 years postoperative. No pain, still some urinary incontinence and impairment in sexual activity.

Case 3

History. A. M., 32-year-old male farmer with a 3-week history of pain in the right leg after thrashing. He was seen by an osteopath and was told his hip "out of place". He received manipulation without benefit. Within a few days after the onset of leg pain, he developed numbness in the "saddle area"; 5 days after the onset of symptoms, the patient developed urinary incontinence and was unable to determine when the bladder was full. Two weeks after the onset, he developed aching in the left leg and a dull backache.

Physical findings. (1) Back signs: some limitation in forward bending. (2) Sciatic signs: none (3) Neurologic signs: (a) Motor: rectal tone very poor, cystometric examination indicated "autonomous neurogenic bladder". (b) Sensory: loss of touch and pain in genital and saddle areas.

Diagnostic impression. Massive disc herniation.
X-rays lumbosacral spine. Normal.
Myelogram. Complete block at L5-S1 intervertebral disc level.
Surgery. Laminectomy with totally extruded disc removed at L5-S1.
Recheck examination over 2 years postoperative. No leg pains, urinary incontinence.

SUMMARY

In summary, there is a type of herniated lumbar disc that is so located as to compress the lower sacral roots centrally within the spinal canal. Compression of these sacral roots results in varying degrees of bowel and bladder incontinence, saddle and genital sensory loss and perhaps a decrease in sexual function. We call this combination of saddle and sensory loss, incontinence and decrease in sexual function a *sacral syndrome.* Herniated lumbar discs that produce a sacral syndrome frequently produce, also, the usual signs and symptoms found with the "average" herniated lumbar disc which include "back signs", "sciatic signs" and "localizing neurologic signs". These patients having the sacral syndrome should all be myelogrammed and laminectomy carried out as a surgical emergency. We have presented three representative cases of herniated lumbar discs producing the sacral syndrome. Even with very prompt surgical intervention, return of function often does not occur.

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MALPRACTICE—NEGLIGENCE OR MISFORTUNE*

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Everyone is familiar with the fact that chance plays a part in our everyday lives. It makes little difference whether we speak of "coincidence," "chance," "fate," "luck" or "predestination." The terminology may vary, depending in large measure upon one's religious or philosophic outlook on life, but we all accept the basic fact that there are forces in operation which we do not understand and which appear to be beyond human control. Thus, in some instances the physician may be more of a spectator than an active participant in the drama of life.

CASE REPORTS

Case 1

Emergency surgery was performed on a 16-year-old boy for acute suppurative appendicitis. The boy had an upper respiratory infection. The patient's parents consented to the surgery but objected to spinal anesthesia. Despite efforts on the part of the surgeon to convince the parents of the advantage of spinal over general anesthesia in this particular case, they steadfastly refused, and appendectomy was subsequently carried out under inhalation anesthesia.

The patient made an uneventful recovery from his surgery and was discharged in 6 days, to be readmitted 5 days later.

Two days after surgery the patient had noted numbness in his left foot, but had failed to mention this to the surgeon. While at home the numbness progressed to involve the opposite leg and trunk up to the nipple line. Muscular weakness appeared in both legs and there was paralysis in the right one. By the time of hospital admission, urinary hesitancy and incontinence had developed. Neurologic examination disclosed loss of pain and temperature sensation from the fifth intercostal area down, complete paralysis of the left leg and muscular weakness in the right leg. Babinski and Kernig reflexes were positive. Abdominal reflexes were absent and ankle clonus was present bilaterally. Spinal fluid examination showed increased pressure, an increase in protein, and a moderate number of white blood cells.

Comment. The final diagnosis proved to be Guillain-Barre syndrome. This patient's spinal cord disease was in no way related to his anesthesia, yet had spinal anesthesia been given it most certainly would have been incriminated, and it takes very little imagination to foretell the jury's decision. A jury has ruled against the physician when complications have arisen after spinal anesthesia, presumably reasoning that serious sequelae do not occur from a properly administered spinal anesthetic, and holding that an untoward result is obvious evidence of either incompetence or negligence.[1]

Case 2

Herniorrhaphy was performed by the Department of Surgery on a 58-year-old white man for right indirect inguinal hernia. The Bassini technique was used and recovery was uneventful.

Several months later, however, the patient was readmitted to the hospital because of a pain in his testicle which had never been present previously. The testis was swollen and edematous with ecchymosis present in the overlying scrotal skin. A diagnosis of torsion of the testis was made, and scrotal exploration revealed partial torsion of the spermatic cord with gangrene of the testis, necessitating orchiectomy.

Comment. These facts would support a malpractice lawsuit: (1) Spontaneous torsion of the spermatic cord occurs almost exclusively in boys and young men; this patient is 58 years old. (2) Operative procedures to repair inguinal hernias all include some manipulation of the spermatic cord. (3) In a majority of cases involving middle aged men, torsion of the spermatic cord after manipulation does not occur without negligence on the part of the physician. Hence, an unlikely candidate for torsion of the spermatic cord suffers a torsion within a reasonably short time after he has a herniorrhaphy in which the spermatic cord must have been manipulated. Thus, "the facts speak for themselves," but in

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this particular case the torsion involved the opposite testicle, making the sequence of events impossible.

Case 3

A 34-year-old white woman presented herself, requesting x-rays of her kidneys. Previously she had undergone studies by the Departments of Surgery and Orthopedics for a chronic low back pain of long duration. All studies were declared normal and the patient was told that the pain was due to posture and marked obesity. She was advised to follow a reducing regime.

The patient requested kidney studies from her former physician, but since her urinalysis was normal and she had no symptoms suggestive of genitourinary dysfunction, her physicians discouraged this, citing the expense and discomfort of intravenous pyelography and the potential hazard of excessive radiation. She insisted on these studies, however, because a neighbor and several friends had convinced her that back pain is a symptom of kidney disease.

The urologist gave in to the patient's insistence, although with little grace, and the x-rays were made revealing a left adrenal tumor the size of a baseball (fig. 1). Adrenalectomy was subsequently performed and the pathologic report indicated that the tumor was a highly malignant adenocarcinoma of the adrenal gland. There was no evidence of metastasis, and the patient is now 5 years postoperative. She is well except for marked obesity and low back pain.

FIG. 1

Comment. The physician is responsible in a legal sense for negligent errors of omission as well as commission. Might not the doctors involved in this case have been judged negligent in failing to detect a malignancy that was readily demonstrable by x-ray?

If occasionally the unfortunate physician is victimized by coincidence, it must in all fairness be conceded that the medical profession sometimes profits from the same capricious fortune. The concept of serendipity has appeared recently in the medical literature. This has been defined as "an apparent aptitude for making fortunate discoveries accidentally."[2] Thus, a good therapeutic result or a brilliant diagnosis may reflect pure chance rather than professional skill. The following two cases illustrate this.

CASE REPORTS

Case 1

A 40-year-old white man had been hospitalized for over a month for undiagnosed fever and progressive physical deterioration. Extensive medical investigation was unrewarding. The patient was cachectic and appeared to be entering the terminal phase of his illness when urologic consultation was requested.

Intravenous urography was undertaken to rule out urologic disease. Retrograde pyelography followed to more clearly delineate the right kidney, which was somewhat suspect for renal neoplasm. The diagnosis remained uncertain, however, and despite the patient's critical condition, aortography was undertaken. After several fruitless attempts to insert the needle into the aorta, the surgeon moved his line of approach slightly to the left to try one more time before abandoning the procedure. On inserting the needle in this new position, frank pus was encountered and gushed forth from the aortogram needle. Subsequently, the patient underwent drainage of a huge left perinephritic abscess and made a dramatic and complete recovery.

Comment. By a happy, but entirely fortuitous, combination of circumstances, an unsuccessful diagnostic procedure became a diagnostic coup and a therapeutic triumph ensued. The surgeon not only failed to suspect left perinephritic abscess, but he believed the pathology to be in the opposite kidney. His only saving grace was

ineptness in needling the aorta, and greater skill in this respect would have resulted only in a missed diagnosis.

Case 2

A 56-year-old white woman was a known hypertensive for 6 years. She was hospitalized for paroxysms of severe headache, dizziness, nausea and vomiting, which lasted several hours and which had been present for the preceding 4 months. During these attacks her systolic blood pressure had reached peaks of 260. She was asymptomatic and only moderately hypertensive between attacks. While hospitalized she felt well except for two attacks during which she experienced her usual symptoms accompanied by blood pressure elevations of 250/150. These attacks showed only moderate response to Regitine, but injection of Mecholyl between attacks did cause a precipitous rise in blood pressure from a resting level to 280/150. Chest x-rays, intravenous and retrograde pyelograms and perirenal air studies were all normal.

Exploration of the abdomen, perirenal and paraaortic areas was unrewarding. Massage of both adrenal glands caused no blood pressure changes. Biopsies of both adrenal cortices were normal. Blood pressure the day after surgery was 90/60, and the highest blood pressure during the postoperative course was 140/70. This patient has been asymptomatic and normotensive during the 4 years since surgery, except for very occasional episodes of mild hypertension.

Comment. This patient underwent exploratory surgery. No pathology was found and nothing constructive was done, yet the patient is markedly improved and the mystery remains.

DISCUSSION

Medical statistics affirm that every medical procedure entails an irreducible minimum of morbidity and mortality in even the most skilled hands. Practical experience indicates that a good result may occur after poor treatment and that good treatment will not necessarily prevent a poor result. Let us concede that medicine is not a pure science and does not inevitably follow established physical laws or mathematical tables. Traditionally, the law recognizes this and has required a physician to possess and employ only the ordinary professional skill and knowledge equal to that possessed by reputable physicians practicing in the same community. Consequently, there has been no penalty attached to an unsatisfactory result provided the physician meets these qualifications.

Events of the past decade, however, indicate that changes may be taking place in this concept in such a way that inevitably the medical profession will be placed in the position of a guarantor of good results. The law never intended this, and the nature of medical practice makes this impossible, but recent verdicts by juries speak louder than abstract theories.

Thoughtful members of both the legal and medical professions feel that in many instances juries no longer adhere to the law and justice becomes warped into a "rule of sympathy" in which the jury gives the plaintiff a verdict, not because of any proved medical negligence, but out of sentiment for the pain, suffering and disability of the unfortunate patient.

Of particular danger is the increasing spread of the doctrine of *res ipsa loquitur* in medical malpractice suits. Briefly stated, this doctrine is a rule of evidence providing that: (1) when the defendant has control over the thing that has caused the injury and (2) the accident is such that would not ordinarily have happened if those in control had not been negligent and (3) the injured party himself did not contribute to the accident, it will raise a presumption that the injury was caused by the defendant's negligence. Upon the plaintiff proving the foregoing elements, the burden is then shifted to the defendant. He must then come forward with evidence to rebut the inference of negligence.

The doctrine of *res ipsa loquitur* was first promulgated by an English Court in 1863 in a case involving the injury of a pedestrian by a barrel of flour which, without explanation, fell from the second story of a warehouse. This doctrine has been universally accepted by various states although a number of them consistently reject its application to medical malpractice cases.

Where the facts do not permit the invocation of the doctrine of *res ipsa loquitur* or in those states not recognizing the doctrine, the patient-plaintiff must prove his allegation of negligence by expert medical testimony of other physicians. Then, at the close of the plaintiff's case, the defendant-doctor normally testifies and introduces testimony of other physicians. He tells what actually happened, and he and his witnesses discuss the accepted method of treatment in the

community. After both sides have presented their evidence, the jury decides this case. To find the defendant-doctor guilty of medical malpractice they must, after weighing all the facts, find that the plaintiff has proved his claim by a "preponderance of the evidence".

However, when the doctrine of *res ipsa loquitur* is introduced, the inference of negligence is raised. This then places the defendant-doctor on the "defensive" prior to any proof of specific acts of negligence on his part. In an inexact science such as medicine where the defendant-doctor takes "control" over a dynamic, complex and not fully understood mechanism such as the human body (as distinguished from a static thing such as a barrel of flour), it does not always follow that "the thing speaks for itself" as evidenced by the cases presented herein. Therefore, although it may be conceded that the overlooked sponge may speak for itself, how much further can the doctrine be applied without manifest injustice. It is our contention that at times the application of *res ipsa loquitur* may be unjust since few things in medicine "speak for themselves."

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EXPERIENCES IN EXTRACORPOREAL CIRCULATION[a]

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Eighteen months ago a program in extracorporeal circulation was initiated at the Lovelace Clinic and Lovelace Foundation. The Kay-Cross oxygenator[12] was chosen for application in this field, and, on the basis of experience elsewhere,[4, 5, 17] certain modifications were designed and tested at the laboratory level before the use of this machine in clinical open heart surgery. Soon thereafter, we were stimulated by the accomplishments of Creech and his associates[9-11] to develop methods for isolation perfusion. Although these clinical applications have been both challenging and rewarding, we believed that the soundness of our total endeavor must be based on an associated program in basic research. Consequently, we have for the past six months studied in dogs the effects of cardiopulmonary bypass on the lungs. In addition, we have gathered data concerning the plasma osmolarity during and after bypass. The purpose of this report is to review some of the interesting features of these experiences.

A MODIFIED FLOW SYSTEM FOR THE KAY-CROSS OXYGENATOR

Although direct gravity drainage of venous blood to the oxygenator was used by Björk[1] in the original rotating disc oxygenator, Cross and Kay[13] have utilized pumping from the caval cannulas with their modification of this apparatus. Neville and associates[18] initiated the use of gravity drainage in this country, and Gross[14] independently perfected and popularized a similar method which included free fall into a receiving chamber, enabling visual evaluation of the venous flow. Olmstead and co-workers[19] recognized early in their work that maintenance of a constant blood level in the rotating disc oxygenator was a critical feature of its operation. Consequently, they devised a flow system having gravity drainage to a small receiving reservoir with venous and arterial pumps regulated by an electrode set-up attached to the arterial end-plate. This system has the disadvantage of requiring separate direct current motors for each pump head, and the equipment has proved rather expensive to duplicate. Kantrowitz and associates[15] have attached a photoelectric cell to regulate the oxygenator blood level by varying the output of the arterial pump.

Our flow system was designed and implemented in the fall of 1958. Previous experience had impressed us with the desirability of sustaining a constant blood level within the oxygenator, and of transferring fluid fluctuations and volume determinations to a chamber with a small cross sectional area. Consequently, a unit was devised which includes gravity drainage of caval blood to a vertical receiving reservoir of large capacity (2650 ml.) but small cross sectional area (1 cm. fluctuation = 50 ml.).[6] A reservoir of smaller diameter gives greater accuracy and is helpful in volume determinations in small patients. Addition of an overflow tap at the desired blood level in the arterial end plate permits bleed-back of excess blood to the receiving reservoir (fig. 1). Constant oxygenator volume is then obtained by simply maintaining the output of the venous pump slightly in excess of that of the arterial pump. This alteration also permits the venous pump to function as a reasonably accurate flow meter. Mayon plastic tubing with an internal diameter of ½ inch is used throughout except for the 5/16-inch intracardiac suction lines and the ⅝-inch internal diameter latex rubber tubing which passes through the pump heads.

[a] From the Lovelace Clinic and Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. Supported by grants from Lovelace Foundation, New Mexico Heart Association and National Institutes of Health (H-4647).

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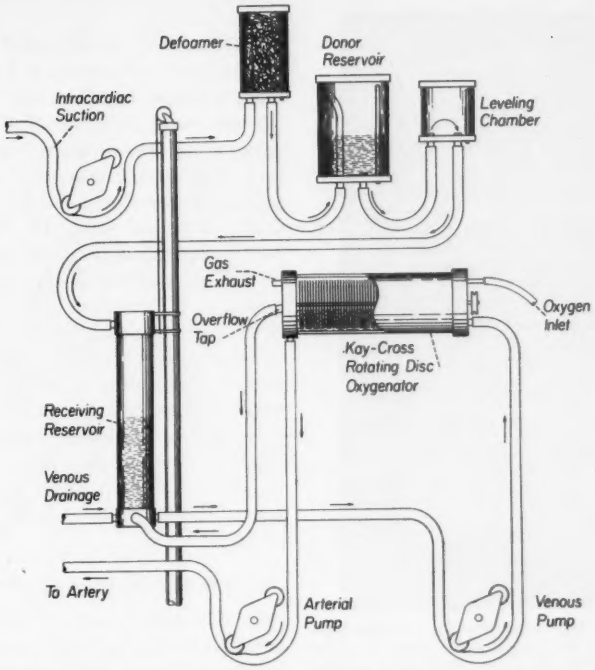

FIG. 1. Diagram of flow system utilized. Two pump suction lines are desirable with a separate roller pump having high output potential provided for each. (From: Cartwright, R. S., and Palich, W. E., J. Thor. Cardiov. Surg., in press.)

With this arrangement the increment of plasma hemoglobin during 45-minute bypass procedures in dogs in generally less than 25 mg. per cent.[9] In our clinical bypass procedures the end plasma hemoglobin level has not exceeded 68 mg. per cent. This indicates blood trauma and approximates that in a standard Kay-Cross unit utilizing direct caval pumping or direct gravity drainage to the oxygenator.

The intracardiac suction set-up shown in figure 1 results in automatic compensation for intracardiac blood returned to the system. Blood entering the top of the donor reservoir causes an equal volume of blood to pass from the donor reservoir to the receiving reservoir via the leveling chamber. Addition of blood to the receiving reservoir in the event of blood loss, is quickly accomplished by lowering the leveling chamber to admit the amount desired. Blood passing downward from the leveling chamber enters the head of the receiving reservoir through a tap which extends to the opposite side of the reservoir, thus directing the flow down the chamber wall. Even at high suction flows, only minute bubbles appear on the surface of the receiving reservoir blood. On no occasion have we noted passage of air bubbles from the receiving reservoir to the oxygenator. A desirable feature of the arrangement is that, aside from minimal mixing, all donor blood is utilized before using blood returned through the suction system.

Maintenance of appropriate negative pressure during venous drainage by gravity is achieved by a simple pulley system regulating the height of the receiving reservoir. A revised, light duty, commercially available winch winds a 250-pound test nylon cord through the inside of the receiving reservoir standard. Only two pulleys are required. One is located at the upper end of the standard and the other is located in the side of the standard at the level of the winch. One hand operation, afforded by adding a rotating handle and an automatic spring lock to

[9] Plasma hemoglobin determinations performed using spectrophotometric method of Cosby[8] with calculated coefficient of variation of 5 per cent.[2]

FIG. 2. Pump oxygenator unit in current use. Infrared lamps and heating pad are controlled by separate variacs. Handle for controlling receiving reservoir height is in door of pump stand.

the winch, allows adjustment over a range of 40 inches. This adjunct permits easy regulation of the venous pressure during and immediately after bypass.

All items essential for control of the pump oxygenator are centralized near the upper right hand corner of the operating table as follows: (1) The venous and arterial pressure manometers are attached to the head of the operating table so that zero levels will be unaffected as the table is raised or lowered. (2) The receiving reservoir, suspended from a standard placed at the front left hand corner of the pump stand, is positioned near the manometers. (3) The donor reservoir-intracardiac suction return system is mounted on the upper pump stand near the receiving reservoir standard. (4) The overflow line passes in clear view between the oxygenator and the receiving reservoir.

One technician can efficiently operate this extracorporeal circulation system. During laboratory experiments and while cleaning and rinsing after usage, the machine can be left functioning without variation in fluid levels with the operator free to perform other duties (fig. 2).

Comment. Our modifications have resulted in (1) accurate extracorporeal volume determinations, a feature most valuable in small patients; (2) automatic volume control within the oxygenator; (3) immediate blood replacement of up to 2000 ml. in the event of sudden blood loss; (4) reliable flow determinations with the partially occlusive venous pump; (5) removal of surface bubbles by way of the overflow tap; (6) transfer of fluid fluctuations to the noncritical receiving reservoir; (7) avoidance of undesirable rigidity of electrical regulating systems; (8) ready control of venous line negative pressure; and (9) increased oxygenating capacity since the constant blood level permits the combined use of spacers 0.14 inch in thickness, convoluted discs, and rotation rates up to 140 r.p.m. In a 21-inch oxygenator, use of these narrow spacers increases the disc capacity from 97 or 98 to a total of 127.

TECHNIQUES IN ISOLATION PERFUSION

Recent introduction of methods for isolating a region of the body and temporarily perfusing a localized area with oxygenated blood containing a chemotherapeutic agent has given

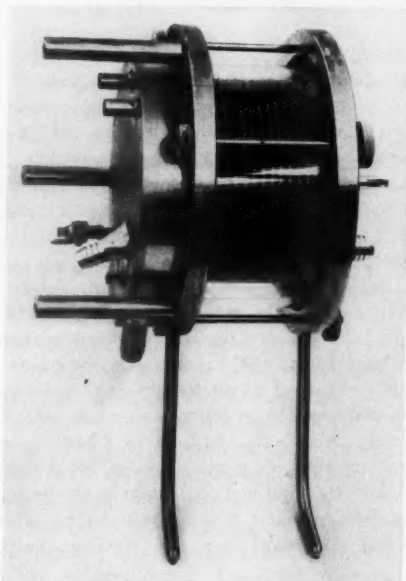

FIG. 3. Three-inch rotating disc oxygenator used in isolation perfusion procedures.

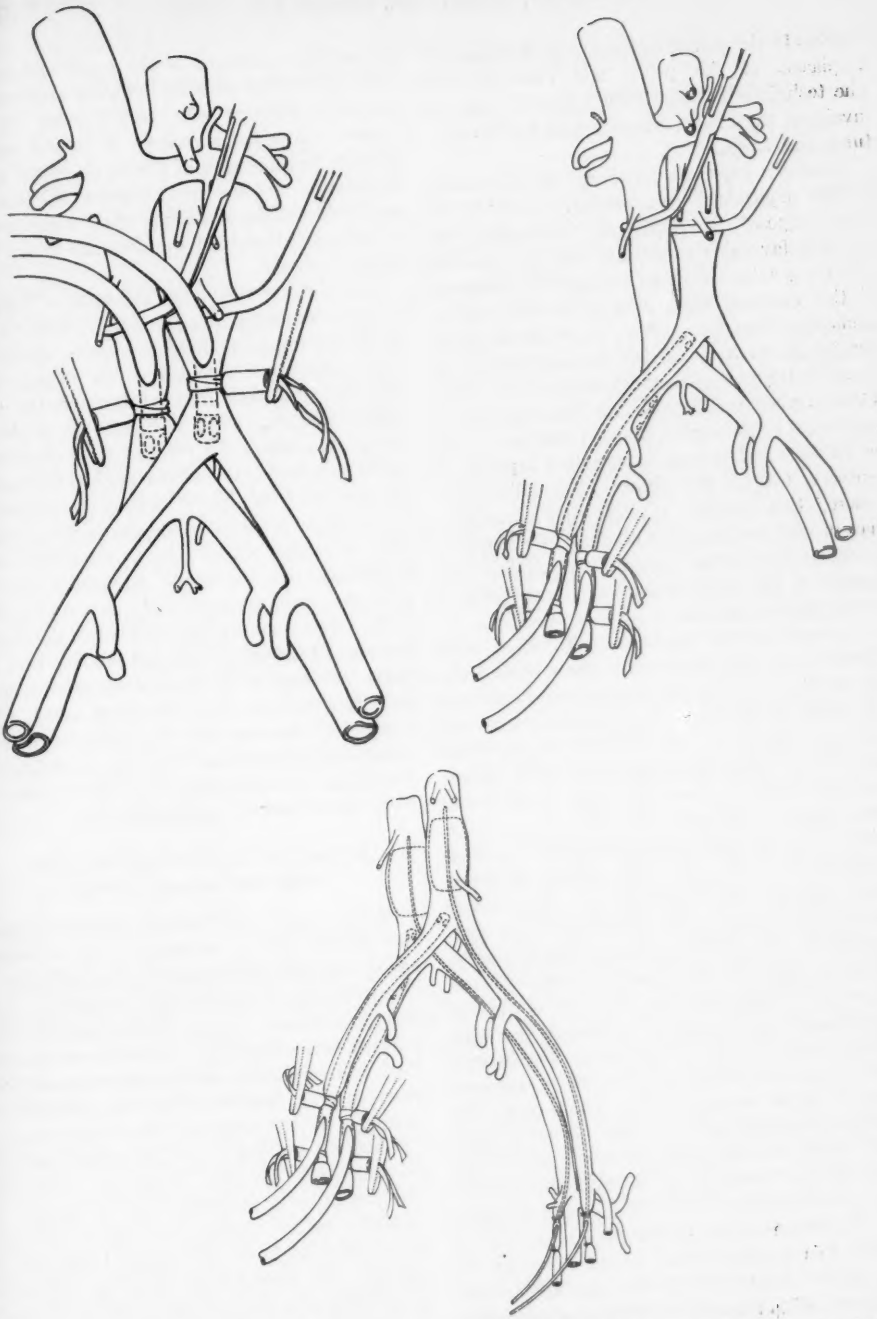

FIG. 4. Methods used in lower abdominal perfusion. Tourniquets (not shown) occlude the circulation to the lower extremities. *A* (*top left*). Direct cannulation of aorta and inferior vena cava. *B* (*top right*). Cannulation via femoral vessels. Major abdominal incision is still required. *C* (*bottom*). Internal vascular occlusion with balloon catheters.

impetus to the palliative treatment of malignant neoplasms of the pelvis and extremities.[9-11] The technique has also been applied to cancers involving the breast, brain, maxillofacial structures and lungs.[10]

Small disc oxygenator. Although the disposable bubble oxygenator commercially available for this purpose* is apparently adequate, our previous favorable experience with the rotating disc oxygenator led us to evaluate the efficiency of this machine when used in localized perfusions. Since low flows suffice, we cut the oxygenator length to 3 inches but retained the other basic features of our modification of the Kay-Cross oxygenator (fig. 3). We now use narrow spacers, 0.14 inch thick, which permit mounting of 16 discs and give an oxygenating capacity in excess of 600 ml. per minute. As described elsewhere,[7] this modified rotating disc oxygenator has proved mechanically efficient in laboratory trials. It has served admirably in clinical perfusions of the upper and lower extremities and of the pelvic abdomen.

Internal vascular occlusion. We have conducted pelvic perfusions with three basic techniques. Our first two patients received perfusions by direct cannulation of the lower aorta and inferior vena cava (fig. 4*A*). Technical complexities of these cannulations led to a second method involving cross clamping of the aorta and inferior vena cava below the renal vessels with retrograde cannulation through the common femoral vessels (fig. 4*B*). This method, however, still retained the disadvantages of a major abdominal incision with consequent pain and morbidity. We therefore devised the technique shown in figure 4*C*. An abdominal incision is not required. Balloon catheters are inserted through the femoral vessels (via the saphenous vein and, when possible, a branch of the common femoral artery) and are passed to a level below the renal vessels. After roentgenologic localization, the balloons are distended to occlude the lower aorta and vena cava. Sufficient pressure is maintained with the use of a mercury column. The balloons are precalibrated so that the pressure required for distention of the balloon is known. In the aorta this pressure must be exceeded by an increment greater than the arterial systolic pressure. With tourniquets inflated on the thighs, an isolation perfusion of the lower abdomen is accomplished by inserting perfusion and drainage cannulas through the contralateral femoral vessels. An initial aortogram is helpful since it permits identification of the levels of the aortic bifurcation and the renal arteries. We are currently developing a cannula which combines the occluding balloon and the drainage lumen in a single catheter.

Perfusions of the entire abdomen of dogs are being conducted in our laboratory, with the use of a balloon to occlude the aorta above the celiac artery and drainage of the inferior cava through a cannula inserted through the right atrial appendage. The distensibility of the inferior cava above the level of the hepatic vein has thus far made the balloon method impractical at this site. Tourniquets exclude the circulation of the lower extremities. Upper body perfusion may be carried out by this same technique with tourniquets on the upper extremities. In this case, the pump oxygenator supports the function of the lower portion of the body while the chemotherapeutic agent is injected above, and the heart and lungs of the patient are used to circulate the chemical. A short acting agent, when applicable, removes the necessity for flushing which would be difficult under the circumstances just given. A larger oxygenator is necessary for these more extensive perfusions.

EXPERIMENTAL OBSERVATIONS DURING CARDIOPULMONARY BYPASS

Plasma osmolarity. Kirklin and associates[16] and Patrick and co-workers[20] have advocated use of salt-poor concentrated serum albumin to counterbalance noncolloidal solutions given during open heart surgery. They recommend that 1 ml. of serum albumin be administered for each 4 ml. of noncolloidal solution given during open heart surgery, believing that this eliminates or decreases the loss of fluids in the tissue spaces.

Using the freezing point depression apparatus manufactured by the American Instrument Company, we have determined the plasma osmolarity before, during and after cardiopulmonary bypass in 6 adult human beings and 13 animals. The results which must be interpreted in the light of a plus or minus 2 per cent error in the method[21] are tabulated in table 1.

Our data support the following conclusions: (1) Right and left atrial blood determinations

* Manufactured by Abbott Laboratories, North Chicago, Illinois.

TABLE 1

Plasma osmolarity and heart-lung bypass (figures represent milliosmols)

Fluids were limited to between 200 and 300 ml. of normal saline during surgery and bypass.*

Dog No.	Before Bypass			During Bypass			After Bypass	
	Right atrium	Left atrium	Oxygenator	Femoral artery			Right atrium	Left atrium
				5 min.	40 min.	80 min.		
Experimental studies								
1	300	310	310					318
2†	284	284	304				297	290
3†	304	300	286					300
4†	282	290	290				297	295
5	313	291	295					305
6	310	308	280				298	300
7	295	284	295					293
8	301	297		325		332		
9	317	315		312	327	310		
10				308	309	305		
11	301	305		320		321		
12	310				327	327		
13†				312		314		
Mean ± S.D.....	302 ± 11	298 ± 11	294 ± 10	315 ± 7	321 ± 10	318 ± 10	297 ± 0	300 ± 9

Patient No.	Before Bypass		After Bypass	Total Fluids during Surgery*
	Antecubital vein	Oxygenator	Femoral artery	
				ml.
Clinical studies				
1		283	275	900
2	270	280	290	450
3	270	278	285	1250
4		300	295	700
5	284	291	290	700
6	293	299	293	700
Mean ± S.D.....	279 ± 11	289 ± 10	288 ± 7	783 ± 270

* Does not include 30 ml. of 5 per cent dextrose in water used as vehicle for heparin in each 500-ml. donor blood bottle.

† Oxygenating gas humidified.

before bypass indicate that water loss in the respiratory system does not cause a detectable difference in the osmolarity of the plasma in the two chambers. (2) Plasma osmolarity does not change materially during cardiopulmonary bypass when conventional techniques are used and excessive hydration is avoided. (3) Humidification of oxygenating gas does not significantly decrease plasma osmolarity. Nonhumidification of oxygenating gas does not significantly increase plasma osmolarity. (4) Administration of concentrated serum albumin to patients and animals undergoing open heart surgery cannot be justified on the basis of changes in plasma osmolarity.

Changes in the lungs during bypass. Because of the high incidence of pulmonary complications after repair of high pressure septal defects, we were led to study the metabolism and function of the lungs during cardiopulmonary bypass.

An animal preparation was used in which right

and left atrial blood flows and pressures were separately determined during bypass. The coronary circulation was excluded from the perfusion by clamps across the aorta and pulmonary artery at the level of the semilunar valves. Care was taken to maintain left atrial pressure slightly greater than right atrial pressure, thus avoiding any possibility of back-flow through the azygous-bronchial venous system. Perfusions were carried out in 15 dogs at a rate of 75 to 100 ml. per kg. of body weight. Under these conditions the lungs were ventilated at the rate of either 2 or 4 L. of nonhumidified air per minute, were statically inflated with air at 7 to 15 cm. of water pressure, or were allowed to remain passively deflated.

The parameters of the pulmonary venous blood varied as follows: (1) with ventilation at the rate of 2 or 4 L. per minute, the oxygen saturation rose to 100 per cent, the hydrogen ion concentration was decreased, and the carbon dioxide tension was markedly reduced; (2) when the lungs were allowed to remain deflated, the oxygen saturation, the hydrogen ion concentration, and the carbon dioxide tension were all altered to levels midway between that of the arterial and venous blood; and (3) with static inflation the oxygen saturation, hydrogen ion concentration, and carbon dioxide tension approximated that noted in the systemic arterial blood.

We have also checked the immediate effect of the varied rates of ventilation on lung compliance with the use of direct pressure-volume curves. Observations in 10 dogs indicate that during cardiopulmonary bypass artificial respiration at the rate of 2 or 4 L. per minute significantly reduces compliance, but that the statically inflated and deflated states do not affect lung elasticity.

Results of these studies have been reported in detail elsewhere.[3]

SUMMARY AND CONCLUSIONS

The overflow system described has proved to be a valuable mechanical adjunct in the operation of the Kay-Cross oxygenator. Although an additional pumping procedure is required, the resultant hemolysis has not been materially greater than that noted with direct gravity drainage to the oxygenator. To us the most significant of the multiple advantages listed have been: (1) improved control of extracorporeal blood volume while avoiding undesirable rigidity; (2) elimination of fluid fluctuations and surface bubbles within the oxygenator, thus permitting the consistently safe use of 0.14-inch spacers in conjunction with convoluted discs, an increased oxygenating capacity resulting; and (3) simplified mechanical operation.

The 3-inch disc oxygenator has proved a good performer in isolation perfusion procedures. We find it advantageous since use of the same equipment utilized in our open heart operations is permitted. Balloon catheters eliminate the necessity of a major abdominal incision in perfusions of the pelvic abdomen, and the feasibility of perfusing the entire abdominal contents by a similar approach is under current investigation in our laboratory.

Plasma osmolarity studies using the freezing point depression apparatus have shown that significant changes in this parameter do not ordinarily occur during or after cardiopulmonary bypass. These findings appear to negate the theoretic reasons for using concentrated salt-poor serum albumin in conjunction with bypass procedures.

Carefully controlled laboratory studies have indicated that when the normal bronchial flow is the sole source of blood perfusing the pulmonary circulation during heart-lung bypass, static inflation results in a more physiologic state than does intermittent ventilation or passive deflation.

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ADDENDUM

Since the submission of this paper for publication, we have successfully utilized a cannula combining the occluding balloon and the drainage lumen in a single catheter (U. S. Catheter and Instrument Company) for isolation perfusion of the pelvis in two clinical cases. A single femoral cutdown suffices under these circumstances.

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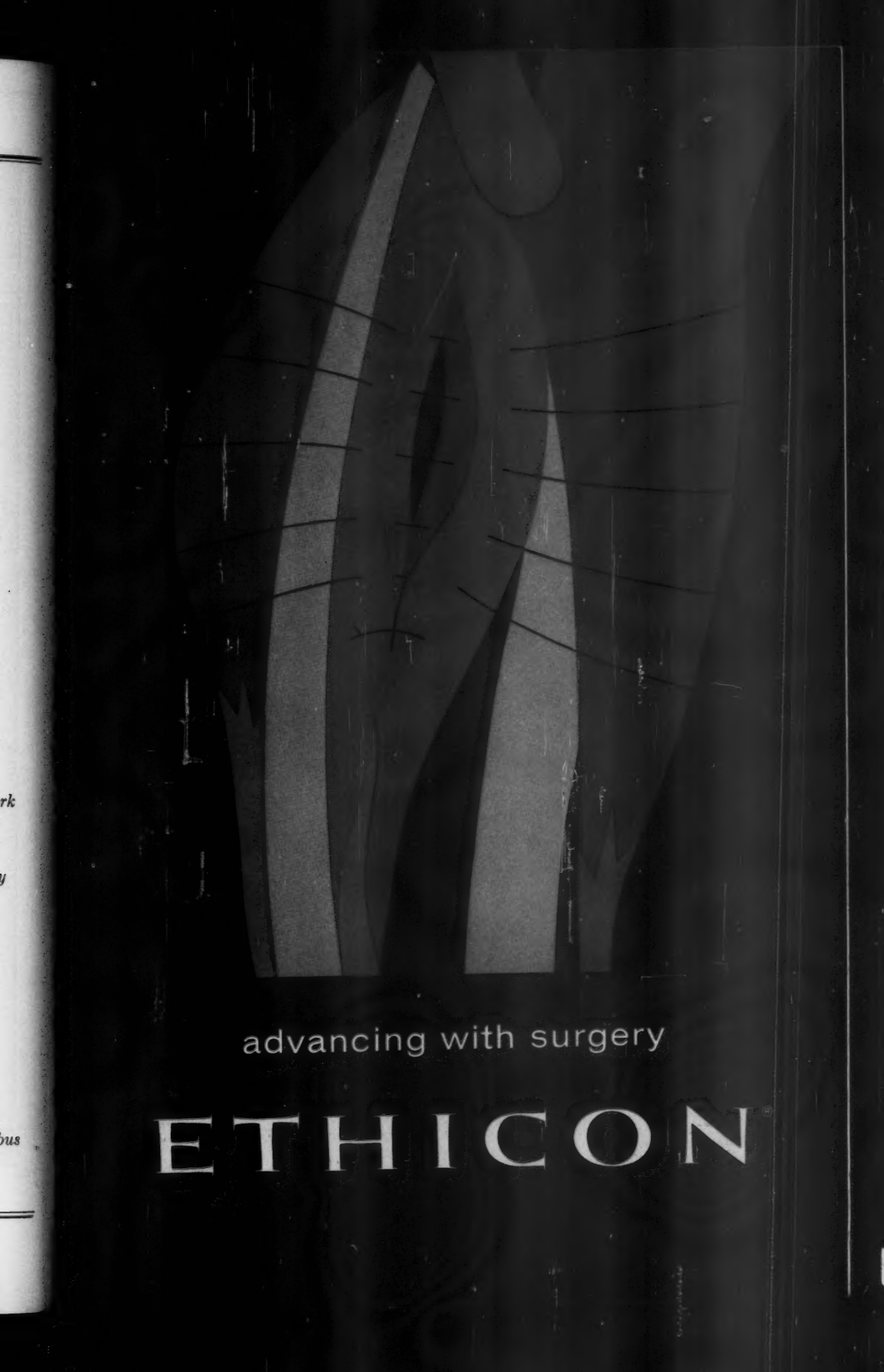
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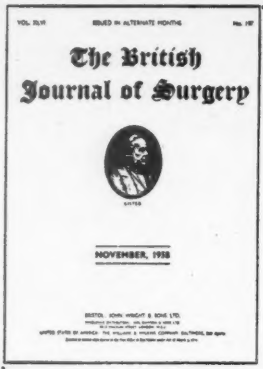

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